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TUPOS — A MULTIPLE SOURCE GAUSSIAN DISPERSION ALGORITHM USING ON-SITE TURBULENCE DATA

by
D. Bruce Turner
Meteorology and Assessment Division
Atmospheric Sciences Research Laboratory
Research Triangle Park, NC 27711
and
Thomas Chico and Joseph A. Catalano
Aerocomp, Inc.
3303 Harbor Boulevard
Costa Mesa, CA 92626

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TUPOS and its postprocessor, TUPOS-P, form a Gaussian model which resembles MPTER but offers several technical improvements. TUPOS estimates dispersion directly from fluctuation statistics at plume level and calculates plume rise and partial penetration of the plume into stable layers using vertical profiles of wind and temperature. The model user is thus required to furnish meteorological information for several heights above-ground in a separate input file.

TUPOS can be used for short-term (hours to days) impact assessment of inert pollutants from single or multiple sources and can be expected to have greatest accuracy for locations within 10 km of the source. Although TUPOIS will make computations for receptors having any ground-level elevation, it is not intended as a complex terrain model, but rather as a model for calculations over flat or gently rolling terrain. TUPOs will optionally treat buoyancy-induced dispersion but does not include building downwash, deposition, or fumigation.

The maximum number of point sources and the maximum number of receptor locations are easily adjusted at the time of program compilation and so have no specific limit. The program as listed in the appendix allows for 25 sources and 180 receptors.

Output from TUPOS consists principally of tape or disk concentration files which are then analyzed and summarized by the postprocessor, TUPOS-P. An hourly concentration file is automatically created by TUPOS; the user has the option of creating a partial concentration file.

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AFFILIATION

Mr. D. Bruce Turner is a meteorologist in the Meteorology and Assessment Division, Environmental Protection Agency, Research Triangle Park, North Carolina. He is on assignment from the National Oceanic and Atmospheric Administration, U. S. Department of Commerce. Mr. Joseph A. Catalano is the technical director of Aerocomp, Inc., Costa Mesa, California and Mr. Thomas Chico is a research meteorologist there.

PREFACE

One area of research within the Meteorology and Assessment Division is development, evaluation, validation, and application of models for air quality simulation, photochemistry, and meteorology. The models must be able to describe air quality and atmospheric processes affecting the dispersion of airborne pollutants on scales ranging from local to global. Within the Division, the Environmental Operations Branch adapts and evaluates new and existing meteorological dispersion models and statistical technique models, tailors effective models for recurring user application, and makes these models available through EPA's User's Network for Applied Modeling of Air Pollution (UNAMAP) system.

Although resembling previous Gaussian dispersion models, TUPOS introduces dispersion as functions of turbulence at plume level, layer by layer plume rise, and plume penetration above the mixing height. Multi-level meteorological information must be furnished by the user. Output is hourly concentrations written to an external file and optionally a second file with concentration contributions from each source.

The first four sections of this document are directed to managers and project directors who wish to evaluate the applicability of the model to their needs. Sections 5 and 6 are directed to engineers, meteorologists, and other scientists who are required to become familiar with the details of the model. Finally, Sections 7 through 9 are directed to persons responsible for implementing and executing the program.

Comments and suggestions regarding this publication should be directed to:

Chief, Environmental Operations Branch
Meteorology and Assessment Division (MD-80)
Environmental Protection Agency
Research Triangle Park, NC 27711.

Although attempts are made to thoroughly check computer programs with a wide variety of input data, errors are occasionally found. Revisions may be obtained as they are issued by completing and returning the form on the last page of this guide.

Technical questions regarding use of the model should be directed to (919) 541-4564. Users within the Federal Government may call FTS 629-4564. Copies of the user's guide are available from the National Technical Information Service (NTIS), Springfield, VA 22161.

The magnetic tape containing FORTRAN source code for TUPOS is contained (along with other dispersion models) in UNAMAP (Version 6), which will become available from Computer Products, NTIS, Springfield, VA 22161 (phone number: (703) 487-4763).

ABSTRACT

TUPOS and its postprocessor, TUPOS-P, form a Gaussian model which resembles MPTER but offers several technical improvements. TUPOS estimates dispersion directly from fluctuation statistics at plume level and calculates plume rise and partial penetration of the plume into stable layers using vertical profiles of wind and temperature. The model user is thus required to furnish meteorological information for several heights above-ground in a separate input file.

TUPOS can be used for short-term (hours to days) impact assessment of inert pollutants from single or multiple sources and can be expected to have greatest accuracy for locations within 10 km of the source. Although TUPOS will make computations for receptors having any ground-level elevation, it is not intended as a complex terrain model, but rather as a model for calculations over flat or gently rolling terrain. TUPOS will optionally treat buoyancy-induced dispersion but does not include building downwash, deposition, or fumigation.

The maximum number of point sources and the maximum number of receptor locations are easily adjusted at the time of program compilation and so have no specific limit. The program as listed in the appendix allows for 25 sources and 180 receptors.

Output from TUPOS consists principally of tape or disk concentration files which are then analyzed and summarized by the postprocessor, TUPOS-P. An hourly concentration file is automatically created by TUPOS; the user has the option of creating a partial concentration file.

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SYMBOLS AND ABBREVIATIONS

Dimensions are abbreviated in terms of the International Standard (SI) for units: Mass = grams (g), Length = meters (m), Time = seconds (s), and Temperature = Kelvin (K).

d -- stack inside diameter (m)

d_z -- the shortest distance between the effective plume height and a bounding surface (m)

E_R -- ground level elevation of receptor (m)

E_S -- ground level elevation of source (m)

f -- stack-tip downwash correction factor

F -- buoyancy flux parameter (m^4/s^3)

F_b -- residual buoyancy at bottom of layer (m^4/s^3)

F_o -- initial buoyancy flux (m^4/s^3)

Fr -- Froude Number

F_R -- residual buoyancy (m^4/s^3)

F_T -- terrain adjustment factor (m)

f_y -- nondimensional function of travel time for horizontal dispersion

f_z -- nondimensional function of travel time for vertical dispersion

g -- acceleration due to gravity (m/s^2)

H -- effective height of plume (m)

h -- stack height above ground (m)

H_a -- adjusted effective height (m)

H_b -- plume bottom (m)

H_t -- plume top (m)

L -- mixing layer depth (m)

Q -- emission rate (g/s)

r -- a ratio used to calculate the height level of maximum concentration

s -- stability parameter (s^{-2})

t -- travel time (s)

T_a -- ambient air temperature (K)

SYMBOLS AND ABBREVIATIONS (continued)

T_h -- ambient air temperature at stack top (K)

T_s -- stack gas temperature (K)

u_h -- wind speed at stack top (m/s)

v_s -- stack gas exit velocity (m/s)

x -- downwind distance (m)

x_f -- distance to final rise (m)

y -- crosswind distance (m)

z -- height above ground (m)

z_b -- height of base of current layer (m)

z_t -- height of top of current layer (m)

ΔH -- plume rise (m)

ΔT -- temperature difference between ambient air and stack gas (K)

χ_p -- pollutant concentration (g/m^3)

$\delta\theta/\delta z$ -- vertical potential temperature gradient of a layer of air (K/m)

π -- pi, 3.14159

σ_a -- standard deviation of the horizontal wind angle (dimensionless)

σ_e -- standard deviation of the vertical wind angle (dimensionless)

σ_v -- standard deviation of the horizontal crosswind component of the wind (m/s)

σ_w -- standard deviation of the vertical component of the wind (m/s)

σ_y -- lateral dispersion parameter (m)

σ_z -- vertical dispersion parameter (m)

σ_{ze} -- effective vertical dispersion (m)

σ_{zo} -- initial vertical dispersion (m)

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In addition to the listed authors of the user's guide, other Aerocomp personnel made important contributions to the document. Ms. Sarah Cunningham prepared all technical illustrations and produced the final document. Editorial review was provided by Ms. Vicki Catalano.

Support of Aerocomp by the Environmental Protection Agency Contract No. 68-02-3750 is also gratefully acknowledged.

EXECUTIVE SUMMARY

TUPOS (TUrbulence PrOfile Sigmas) is a Gaussian plume steady-state model which calculates dispersion using measured (or inferred) turbulence data (wind fluctuation standard deviations) at plume height. The model can be used to assess air pollutant impact from single or multiple sources over level or gently rolling terrain and can be expected to have greatest accuracy for locations within 10 km of the source. Gaussian assumptions and techniques are used to perform concentration estimates hour by hour, considering each hour as a steady-state period.

Information must be furnished by the user for each simulated hour at several levels for the five variables: ambient air temperature, wind direction, wind speed, standard deviation of wind azimuth, and standard deviation of wind elevation angle. These parameters are interpolated vertically for calculating plume rise, dilution, plume dispersion, and transport. This profile information must be provided in sufficient detail so that linear interpolation between levels is reasonable. One of the levels specified must be that of the mixing height.

Source parameters are physical stack height above ground, stack top inside diameter, stack gas temperature, stack gas exit velocity, and pollutant emission rate. Optionally, values for three variables: stack gas temperature, stack gas exit velocity, and emission rate can be entered hourly.

Optional features of the TUPOS computer code include:

- Stack downwash, buoyancy-induced dispersion, and gradual plume rise;
- Terrain adjustment as a function of stability category; and

- An optional program-generated polar coordinate grid, with sector size and azimuth spacing entered as input.

To take advantage of the vertical profiles of temperature and wind speed provided by the input, a layer-by-layer plume rise algorithm (Turner, 1985) is used which also considers partial penetration of the plume into elevated stable layers. Dispersion is estimated from the wind fluctuations at plume height using the method of Irwin (1983).

The maximum number of point sources and the maximum number of receptor locations are easily adjusted at the time of program compilation and so have no specific limit. The program as listed in the appendix allows for 25 sources and 180 receptors.

Output from TUPOS consists principally of tape or disk concentration files which are then analyzed and summarized by the postprocessor, TUPOS-P. An hourly concentration file is automatically created by TUPOS; the user has the option of creating a partial concentration file.

By making the number of sources and receptors easily adjustable at time of compilation and removing functions that are largely bookkeeping to the post processor, the TUPOS system should be easily adaptable to computer systems with small core storage.

SECTION 1

INTRODUCTION

TUPOS is a multiple point source Gaussian dispersion algorithm which possesses many of the options and capabilities of MPTER. However, its differences from MPTER and other prior UNAMAP dispersion models are significant. For instance, TUPOS utilizes standard deviations of hourly wind fluctuations, in its dispersion algorithm, in the manner discussed by Irwin (1983). Also introduced in this model are layer-by-layer plume rise according to Turner (1985) and plume penetration above the mixing height (Briggs, 1975). A brief historical perspective on these new refinements is presented next.

Prior to the development of TUPOS, most UNAMAP dispersion algorithms utilized the σ-curves of the Pasquill-Gifford (P-G) scheme which are based on ground-level releases and short-range dispersion studies. Despite cautionary remarks from Pasquill (1976), the P-G dispersion estimates have been extrapolated to elevated sources and receptor distances far beyond their experimental basis.

Participants of an American Meteorological Society Workshop on stability classification schemes and sigma curves (Hanna et al., 1977) recommended refinement of methods for estimating the vertical and lateral dispersion parameters used in Gaussian plume models, especially for elevated releases. Draxler's (1976) and Cramer's (1976) dispersion characterizations employing wind turbulence data were mentioned as examples of available methods, but it was suggested that the scatter in the data precluded recommending a particular scheme. A review panel (Randerson, 1979) stressed the usefulness of examining errors one might encounter using a particular dispersion characterization as compared to using other available schemes.

Irwin (1983, 1984) reviewed alternative dispersion schemes using data collected during 17 field tracer experiments conducted at 11 sites. From this review, Irwin synthesized a scheme from the characterizations of Cramer and Draxler which is robust and behaves well over a variety of dispersion conditions. This scheme requires specification of the variances of the vertical and lateral wind directions at plume height. TUPOS was designed to make use of on-site turbulence measurements according to these methods developed by Irwin.

Meteorological input to TUPOS consists of layer-by-layer values for five variables: wind direction, wind speed, temperature, standard deviation of wind azimuth, and standard deviation of wind elevation angle. It is assumed that layer heights are chosen so that linear interpolation of these five variables between levels will be appropriate. A meteorological processor, MPDA-1 (Paumier et al., 1986) produces information compatible with the input requirements for TUPOS. This processor is capable of using a variety of meteorological data sources to produce the resulting profiles.

Nearly all of the air quality simulation models, made available to date through the UNAMAP system (U.S. EPA, 1983), use plume rise methodology that depends upon only the wind speed estimated at the physical stack height and the surface-based Pasquill stability class and for the stable conditions, Pasquill stability classes E and F, set temperature gradients, $\delta\theta/\delta z$, of 0.02 K/m and 0.035 K/m, respectively. However, if available, it is more desirable to use vertical profiles of temperature and wind speed. TUPOS employs a layer-by-layer plume rise algorithm, developed by Turner (1985), that utilizes this profile data.

Full reflection or full penetration of plumes in the vicinity of the mixing height, used in previous models, is also overly simplistic. That is, if the plume centerline is above the mixing height, then there is no contribution of the plume to concentrations below the mixing height; or, if the plume centerline is below the mixing height, then the entire plume is eddy-reflected downward from the mixing height. TUPOS adopts a method suggested by Briggs (1975) and modified by Turner (1985) for treatment of partial plume penetration above the mixing height.

This user's guide is divided into three parts, with each part directed to a different audience: managers, dispersion meteorologists, and computer specialists. The first four sections are aimed at managers and project directors who wish to evaluate the applicability of TUPOS to their needs. Sections 5 and 6 are directed to dispersion meteorologists or engineers who are required to become familiar with the details of the model. Finally, Sections 7 through 9 are directed to persons responsible for implementing and executing the program. A listing of the FORTRAN source code is included in Appendix A.

The user's guide refers in various places to the features and limitations of MPTER. This is done for the benefit of users familiar with MPTER who now need some of the more refined features available in TUPOS.

SECTION 2

DATA-REQUIREMENTS CHECKLIST

To estimate concentrations for any simulated time period, data for program control, as well as information on emissions, meteorology, and receptors are required. These are mentioned briefly here; more detail on proper formatting for data entry to the program is covered in Section 8.

PROGRAM CONTROL DATA

The following control information is required for a simulation:

- Headings (for output),
- Meteorological data file identifier and creation date,
- Starting time (year, Julian day, and hour),
- Abbreviation for pollutant considered,
- Conversion for user units, and
- Pollutant half-life.

In addition, the user must indicate whether the following options are to be employed:

- Terrain adjustment,
- Stack downwash,
- Gradual plume rise, and
- Buoyancy-induced dispersion.

Output principally consists of tape or disk files which are then analyzed and summarized by a separate postprocessor TUPOS-P (Turner, et al, 1985). An hourly concentration file is automatically created by TUPOS; the user has the option of creating a partial concentration file. For convenience, a brief summary of the simulation is printed; however, the user is encouraged to exercise the postprocessor, TUPOS-P (Turner et al., 1986), to obtain a detailed listing of the results.

EMISSION DATA

The following information is required for each point source:

- East and north coordinates of the point source (user units),
- Pollutant emission rate (g/s)
- Physical stack height (m),
- Stack gas temperature (K),
- Stack inside diameter (m), and
- Stack gas exit velocity (m/s).

The east-north coordinate system can be provided in any consistent units. Also, the stack ground-level elevation is required if the terrain adjustment option is used.

METEOROLOGICAL DATA

Hourly meteorological data are required for specific levels. The user may prepare the data in the format specified in Section 8 or data prepared by the Meteorological Processor for Dispersion Analyses, MPDA-1 (Paumier, et al, 1986), may be used. The hourly meteorological data needed for the computations are as follows:

- Year,
- Julian day,
- Hour,
- Number of vertical levels,

- Level number corresponding to the mixing height,
- Stability category,
- Height above ground of each level (m),
- Ambient air temperature at each level (K),
- Wind direction at each level (degrees),
- Wind speed at each level (m/s),
- Standard deviation of the azimuth angle (radians) at each level, and
- Standard deviation of the elevation angle (radians) at each level.

There are four stability categories in TUPOS: unstable, daytime neutral, nighttime neutral, and stable designated 1 to 4, respectively. These can be defined using the ratio of Monin-Obukhov length to mixing height. (The stability category is contained in the output from MPDA-1.)

It is assumed that the variation of meteorological parameters with height is provided in sufficient detail such that linear interpolation with height between levels yields reasonable values. Any information required for a height below the height of the lowest level is assigned the value of the lowest level. Similarly, any information required for a height above the height of the highest level is assigned the value of the highest level.

RECEPTOR DATA

The user has the option of designing his or her own receptor grid or instructing TUPOS to generate a polar coordinate receptor grid (see Section 8). In either case, the location (user length units) and, if the terrain adjustment option is used, the ground-level elevation (user height units) are required on input. Additionally, for the user-supplied receptors, the receptor height above ground (m) must be given.

SECTION 3

FEATURES AND LIMITATIONS

TUPOS is a Gaussian plume steady-state model using measured (or inferred) turbulence data (wind fluctuation standard deviations) as part of the meteorological input. It is a useful short-term (hours to days) algorithm to evaluate the effects of multiple point sources in the near-field (within 10 km). It is the intent of the authors that TUPOS be applied to sources whose effluent is dominated by buoyancy or momentum (not heavier than air releases). Only simple terrain adjustments are made; it is not expected that plume impaction be considered. The model includes the following optional computational features in common with MPTER:

- Stack downwash,
- Buoyancy-induced dispersion,
- Gradual plume rise, and
- Terrain adjustment as a function of stability category.

Modeling features unique to TUPOS include:

- Layer-by-layer plume rise according to Turner (1985), and
- Partial plume penetration above the mixing height (Briggs, 1975 and Turner, 1985).

TUPOS retains limitations typical of Gaussian plume models including:

- No consideration of nonlinear pollutant removal or chemical reactions,
- No consideration of spatial variation in meteorology, and
- No consideration of increased horizontal dispersion due to wind direction shear through the vertical extent of plumes.

Also, TUPOS has no provision for calculating the effects from area or line source emissions or consideration of building downwash or fumigation.

Table 1 presents a comparison of TUPOS features with those of other air quality models. TUPOS has all the features of MPTER including terrain adjustment, stack downwash, gradual plume rise, buoyancy-induced dispersion, exponential removal mechanism, and a standard steady-state Gaussian plume dispersion algorithm. Air pollution concentrations are simulated for each one hour period using hourly average meteorology. During the calculation, steady-state conditions are assumed. The major improvements of TUPOS over MPTER are (1) TUPOS calculates dispersion parameters from on-site measured turbulence data instead of the Pasquill-Gifford (P-G) scheme (Pasquill, 1961) and (2) the multi-layer approach to plume rise, dilution, plume spreading, and transport considered by TUPOS. Moreover, TUPOS can simulate partial plume penetration. Table 2 summarizes the differences in approach between TUPOS and MPTER.

TABLE 1. COMPARISON OF TUPOS TO OTHER COMMONLY USED AIR QUALITY MODELS.

X -- used by model O -- optional	TUPOS	PTPLU	INPUFF	PTMTP	RAM	MPTER	CRSTER	VALLEY	PAL	MESOPUFF
MODEL TYPE										
Gaussian plume	X	X		X	X	X	X	X	X	
Gaussian puff			X							X[1]
GRID SIZE			100							1600
AVERAGING PERIOD										
Hour		X	O	X	X	O	X		X	O
3-hour	O		O		O	O	X		O	O
24-hour	O		O	X	O	O	X	O	O	O
Annual	O					O	X	O		
TYPE OF SOURCES										
Single stack	X	X	X	X	X	X	X	X	X	X
Multiple stacks	25[2]			25	250	250	19[3]	50[4]	99	10
Area sources					100			50[4]	99	
Line sources									99	
RECEPTORS										
Number of	180[2]		25	30	180	180	180	112	99	X[5]
Cartesian coordinates	X				X	X				X
Cartesian coordinates w/ elevations	X		X	X		X			X	
Polar coordinates	X				X	X				
Polar coordinates w/ elevations	X					X	X	X		
Program generated grid					O					
METEOROLOGICAL DATA										
Preprocessor	X				X	X	X			X
STAR file								X		
User specified	O		X	X	O	O		X	X	
Program generated		X								
POLLUTANT										
Non-reactive	X	X	X	X	X	X	X	X	X	X[6]
Half-life	O				O	O		O		
PLUME RISE										
Stack tip downwash	O	O	O		O	O	O			
Gradual plume rise	O	O		X	O	O	O	O	X	
Buoyancy-induced dispersion	O	O	O		O	O		O		
TERRAIN ADJUSTMENTS	O		O	O		O	O	O		O

(1) Specially suited for long range transport.

(2) Maximum number of point sources and receptors can be changed at time of program compilation.

(3) Co-located stacks.

(4) Total of 50 point and/or area sources.

(5) Concentrations computed at each grid point and at up to 50 user-specified receptors.

(6) Linear conversion of SO_2 to SO_4 and linear deposition of SO_2 and SO_4.

TABLE 2. DIFFERENCES IN APPROACH BETWEEN MPTER AND TUPOS.

Technical feature	MPTER	TUPOS
Dispersion	Pasquill-Gifford	Turbulence data
Meteorological data requirements	Pasquill stability class, wind speed/direction, temperature, and mixing height	stability category, mixing height, and at each input level: wind speed/direction, temperature, σ_a and σ_e
Determination of plume level meteorology	Wind speed power law. Temperature and wind direction independent of height	Linear interpolation between vertical levels
Plume rise	Calculated according to surface temperature, stack top wind speed, and for stable conditions a standard inversion strength corresponding to Pasquill stability class	Calculated through each layer based upon vertical profiles of wind and temperature.
Partial plume penetration through the mixing height	All of plume either above or below mixing height	Considered (based on work of Briggs, 1975)
Source and receptor accommodations	250 point sources 180 receptors	Can be adjusted prior to compilation to process any number of sources and receptors
Vertical layers	1	Can be adjusted to any number of levels

SECTION 4

BASIS FOR TUPOS

This section presents a brief narrative highlighting important aspects of the modeling approach. A detailed technical description, including equations, is provided in Section 5. Figure 1 illustrates the multi-layer approach incorporated in TUPOS. It should help the reader visualize some of the items discussed below. Although the structure of TUPOS resembles previous Gaussian models, such as MPTER (Pierce and Turner, 1980) it differs in several respects. Plume dispersion is estimated from fluctuation statistics at plume level. Multi-level meteorological information must be input. Plume rise and partial penetration of the plume into stable layers make use of the vertical profiles of wind and temperature.

METEOROLOGICAL PARAMETERS

Multi-level meteorological information for levels above ground must be furnished in a separate input file. Required parameters for each level include: ambient air temperature, wind speed and direction, the standard deviation of wind azimuth, σ_a, and the standard deviation of wind elevation angle, σ_e. It is assumed that this information is sufficiently detailed such that linear interpolation between levels characterizes the meteorology at any particular height. One of the levels specified must be that of the mixing height. Also, in order to properly specify the potential temperature change with height, it is good practice to specify at least one data level above the mixing height.

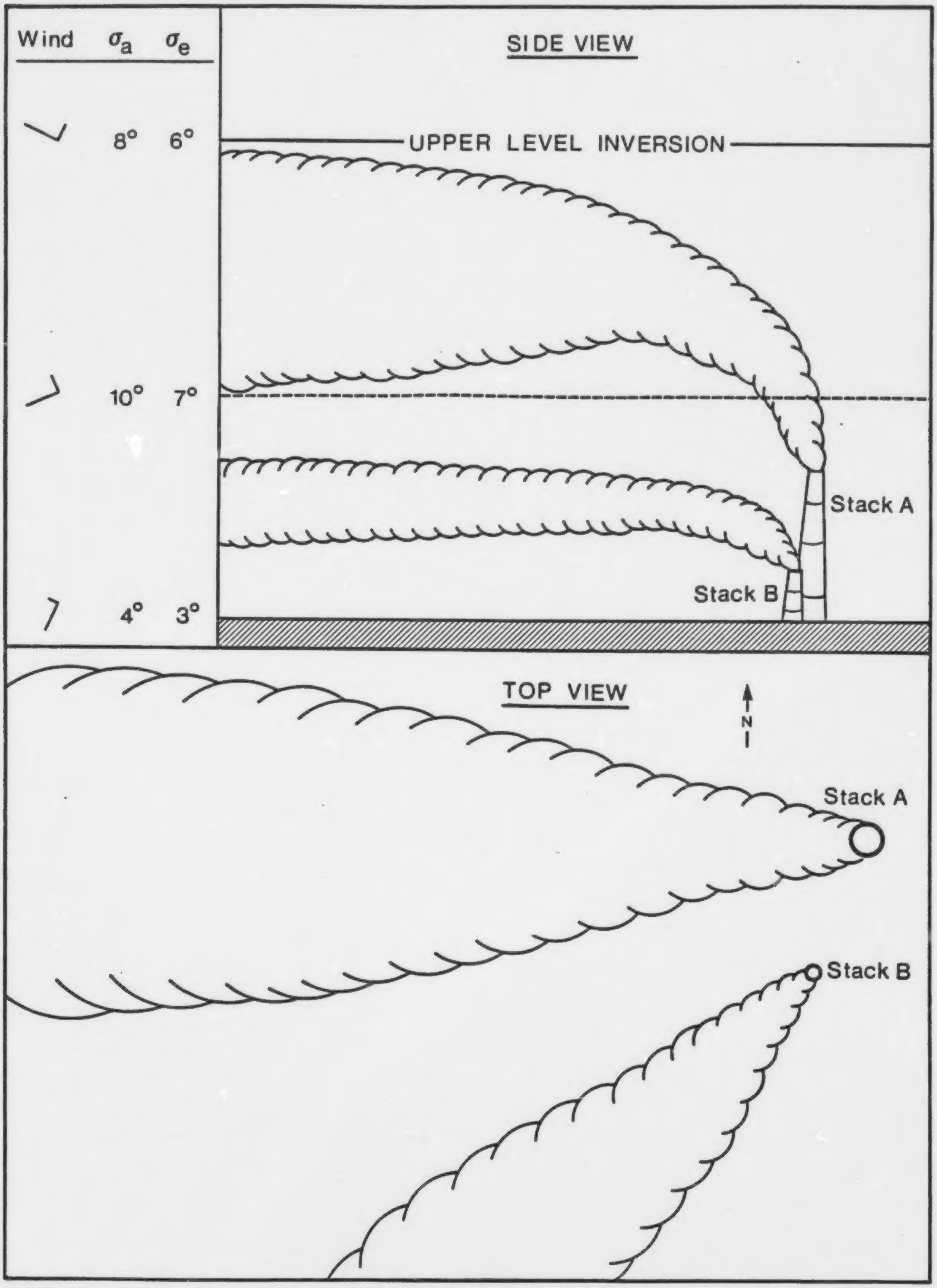

Wind
σ_a
σ_e
8°
6°
10°
7°
4°
3°
SIDE VIEW
UPPER LEVEL INVERSION
Stack A
Stack B
TOP VIEW
N
Stack A
Stack B

Figure 1. Schematic of multi-layer approach incorporated in TUPOS.

GAUSSIAN PLUME METHODOLOGY

Gaussian plume methodology assumes that pollutant concentrations from a continuously emitted plume are proportional to the emission rate, and are diluted by the wind at the point of emission at a rate inversely proportional to the wind speed. It also assumes that the time-averaged (over approximately one hour) pollutant concentrations crosswind and in the vertical near the source are closely described by Gaussian or normal distributions. The standard deviations of a plume concentration in these two directions are empirically related to the levels of turbulence in the atmosphere and increase with distance from the source.

Calculations are made for each simulated hour as if in steady-state conditions; that is, concentrations for a given hour are independent of those from previous hours. For receptors near the sources, this is a reasonable assumption.

Calculations for each hour are organized by source, such that all calculations are made for one source before proceeding to the next. In this regard, the total concentration for a given hour at a particular receptor is the sum of the estimated contributions from each source. This is also a reasonable assumption if there are no synergistic effects among different species from different sources. Emissions for only one pollutant are allowed for an individual run of TUPOS.

PLUME RISE

TUPOS employs a layer-by-layer plume rise algorithm developed by Turner (1985). In this approach, plume rise through each vertical layer is calculated taking into account the variation of temperature and wind speed with height.

Stack-tip downwash (optional) can be considered by applying a correction factor to the estimated plume rise (Bjorklund and

Bowers, 1982). This correction factor accounts for downwash in the lee of stacks during periods when the wind speed at the stack top is greater than or equal to 0.67 times the stack gas exit velocity.

Gradual plume rise is available as an optional calculation in TUPOS. Although the two-thirds dependence for rising plumes determines average plume height with distance quite well, the dispersive processes that occur during buoyant rise are thought to be different from those that occur during steady-state transport. The on-site dispersion parameters represent horizontal and vertical dispersion about a horizontal plume, which may or may not be appropriate for estimating dispersion during the plume rise phase. By making computations with and without gradual plume rise, potentially high concentrations can be identified. When gradual rise is not employed, computations use only the final effective plume height. Normal application of this model uses only the plume final rise. However, gradual rise is evaluated and used in determining buoyancy-induced dispersion.

Instead of the simplistic approach of either full reflection or complete penetration of a plume in the vicinity of the mixing height, TUPOS adopts the partial plume penetration technique suggested by Briggs (1975) and modified by Turner (1985). Assuming the initial vertical plume profile to be a "top hat" distribution, the plume top and bottom are compared with the mixing height. Then adjustments are made to the plume rise, and emission rate to account for the partial penetration of the plume above the mixing height.

DISPERSION

Dispersion is characterized by a scheme described by Irwin (1983), which utilizes on-site measured (or inferred) turbulence data. The method requires specification of the variances of the vertical and lateral wind directions at plume height and the stability category (i.e., unstable, neutral-day, neutral-night, or stable). It should be emphasized that the turbulence data must be supplied in sufficient vertical detail such that linear interpolation between levels is appropriate.

Buoyancy-induced dispersion calculations (optional) are offered because emitted plumes undergo a certain amount of growth during the plume rise phase. This is due to the turbulent entrainment of ambient air. During the initial growth phases of release, the plume is assumed to be nearly symmetrical about its centerline; hence, the buoyancy-induced dispersion in the horizontal direction is modeled as equal to that in the vertical direction. The maximum effects on ground-level concentrations occur for short heights of release combined with large plume rise, but, in general, buoyancy-induced dispersion has only a small effect on maximum surface concentrations from elevated releases.

SECTION 5

TECHNICAL DESCRIPTION

TUPOS is a multiple point source, steady state Gaussian disperison algorithm that estimates dispersion directly from turbulent fluctuation statistics at plume level and calculates plume rise and partial penetration of the plume into stable layers using vertical profiles of wind and temperature. TUPOS can be used for short term (hours to days) impact assessment of inert pollutants from single or multiple sources and can be expected to have greatest accuracy for locations within 10 km of the source.

METEOROLOGICAL PARAMETERS

In order to have turbulent fluctuations at plume level and to calculate plume rise and penetration, TUPOS requires values for five variables: wind direction (wind azimuth), wind speed, temperature, standard deviation of wind azimuth angle, and standard deviation of wind elevation angle for a number of heights above the ground. Sufficient heights should be used so that linear interpolation of these values in the vertical between levels will result in a reasonably accurate value for that height. One of the levels specified must be that of the mixing height. In order to properly specify the potential temperature change with height, it is good practice to specify at least one data level above the mixing height. The number of levels and the height above ground of each level can be changed on the data from hour to hour. A meteorological processor, MPDA-1 (Paumier, et al. 1986) can produce a data file that is compatible with the input requirements for TUPOS. This processor is capable of using a variety of meteorological data sources to produce the required data. After calculating the height of the plume centerline, interpolated values of the meteorological parameters for plume centerline height are determined and used to determine plume transport direction and the plume dispersion.

GAUSSIAN PLUME EQUATIONS

Given a coordinate system with the origin at the ground, x upwind from the receptor, y crosswind, and z vertical (see Figure 2), the Gaussian equations for a continuous release are as follows:

$$\chi_p = Q/u \cdot g_1/(\sqrt{2\pi}\sigma_y) \cdot g_2/(\sqrt{2\pi}\sigma_z), \qquad (1)$$

$$\chi_p = Q/u \cdot g_1/(\sqrt{2\pi}\sigma_y) \cdot 1/L \text{ and} \qquad (2)$$

$$\chi_p = Q/u \cdot g_1/(\sqrt{2\pi}\sigma_y) \cdot g_3/(\sqrt{2\pi}\sigma_z). \qquad (3)$$

g_1, g_2, and g_3 are defined as follows:

$$g_1 = \exp(-0.5y^2/\sigma_y{}^2), \qquad (4)$$

$$g_2 = \exp[-0.5(z-H)^2/\sigma_z{}^2] + \exp[-0.5(z+H)^2/\sigma_z{}^2], \text{ and} \qquad (5)$$

$$g_3 = \sum_{N=-\infty}^{\infty} \{\exp[-0.5(z-H+2NL)^2/\sigma_z{}^2] + \exp[-0.5(z+H+2NL)^2/\sigma_z{}^2]\}. \qquad (6)$$

For stable conditions or unlimited mixing, Eq. 1 should be used. For unstable and neutral conditions, where σz is equal to or greater than 1.6 L, Eq. 2 should be used. For unstable and neutral conditions where σz is less than 1.6 L, Eq. 3 should be used provided that both H and z are less than L.

Definitions and units of variables mentioned in this subsection are summarized in Table 3.

TABLE 3. DEFINITION OF VARIABLES USED IN GAUSSIAN PLUME EQUATIONS

Symbol	Definition	Units
χ_p	concentration	g/m^3
Q	emission rate	g/sec
u	wind speed	m/sec
σ_y	standard deviation of plume concentration - horizontal distribution	m
σ_z	standard deviation of plume concentration - vertical distribution	m
L	mixing height	m
H	effective height	m
z	receptor height above ground	m
y	crosswind distance	m
g_1	horizontal dispersion function	--
g_2, g_3	vertical dispersion functions	--

PLUME RISE

Equations for estimating plume rise into neutral or unstable conditions above the stack were modified from techniques presented by Briggs (1983 and 1984). Equations for estimating plume rise within stable layers both for calm and windy conditions are from Briggs (1975).

These procedures are designed to take advantage of methods developed by Briggs to consider the vertical profiles of wind and temperature in estimating plume rise. It is assumed that temperature and wind speed are available for at least two levels above the ground. It is also assumed that the level of the mixing height is available. It is recommended that at least one data level above the mixing height be provided so that the potential temperature with height above the mixing height may be calculated.

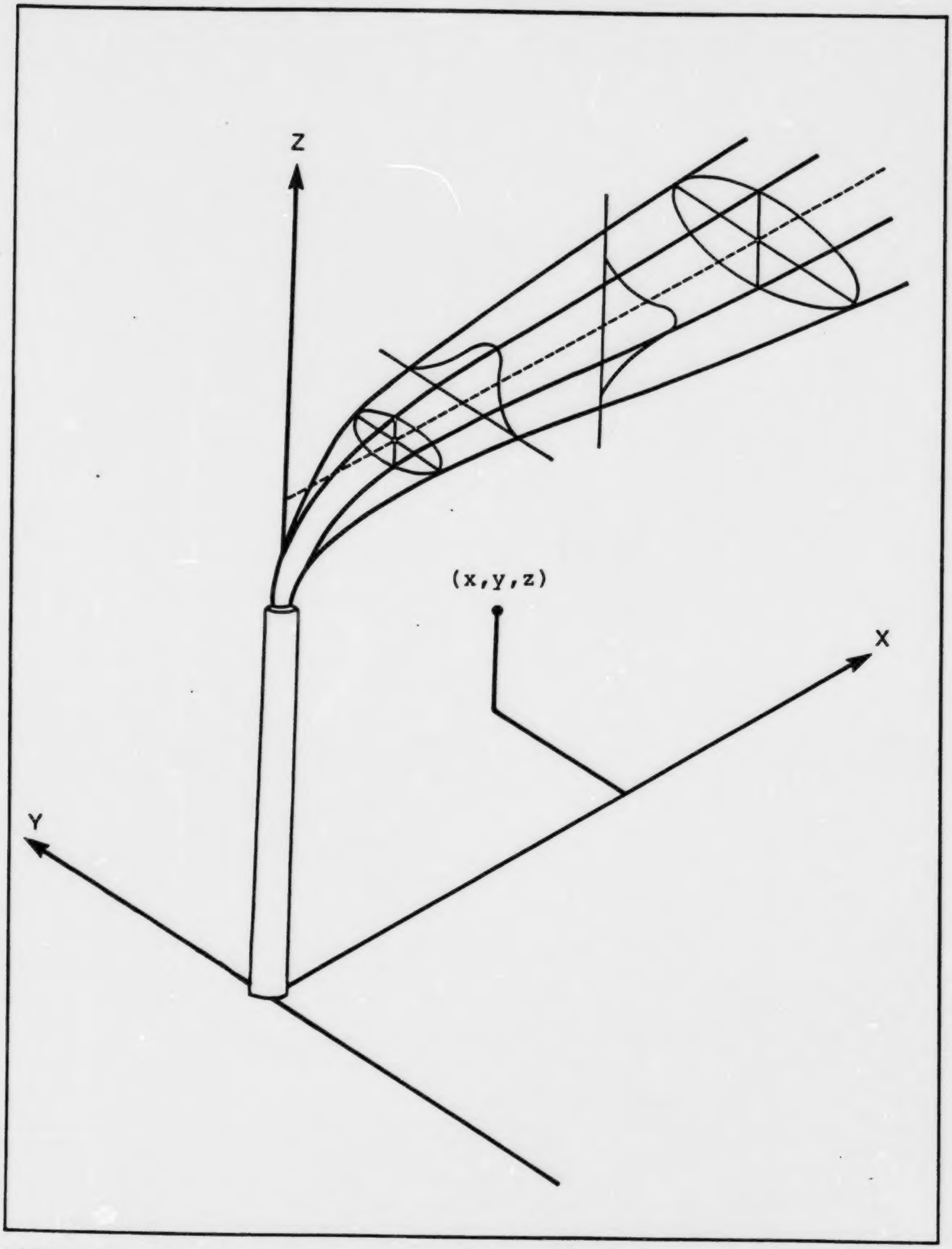


Figure 2. Coordinate system showing Gaussian distribution in the horizontal and vertical.

The meteorological information given at different levels should be sufficiently dense in the vertical so that linear interpolation of the parameters between levels yields reasonable values.

Stack Tip Downwash

TUPOS considers the effects of stack downwash by applying a correction factor to the estimated plume rise. According to Bjorklund and Bowers (1982), the stack-tip downwash correction factor, f, (which is multiplied times the calculated plume rise) is defined by

$$f = \left\{ \begin{array}{ll} 1 & \text{for } u_h < v_s/1.5 \\ (3v_s - 3u_h)/v & \text{for } v_s/1.5 < u_h < v_s \\ 0 & \text{for } u_h > v_s \end{array} \right\} . \qquad (7)$$

This correction factor accounts for the effects of downwash in the lee of stacks during periods when the wind speed at the stack height is greater than or equal to 0.67 times the stack gas exit velocity. It is not used (i.e., $f = 1$) for stacks with Froude numbers less than 3.0. The Froude number, Fr, is the ratio of the inertial force to the force of gravity for a given fluid flow. Briggs (1969) defines the Froude number for stack gas releases as

$$Fr = v_s^2/[g\ d\ (T_s - T_a)/T_a] , \qquad (8)$$

where v_s is stack gas exit velocity, d is stack diameter, g is acceleration of gravity (9.806 m sec^{-2}), and T_s and T_a are temperatures of the stack gas and ambient air, respectively.

Determination of Stable or Neutral-Unstable Conditions

In order to calculate plume rise, TUPOS must determine the atmospheric thermal structure and decide whether the plume is dominated by buoyancy or momentum. The skeletal outline for calculating the plume rise is illustrated in Figure 3.

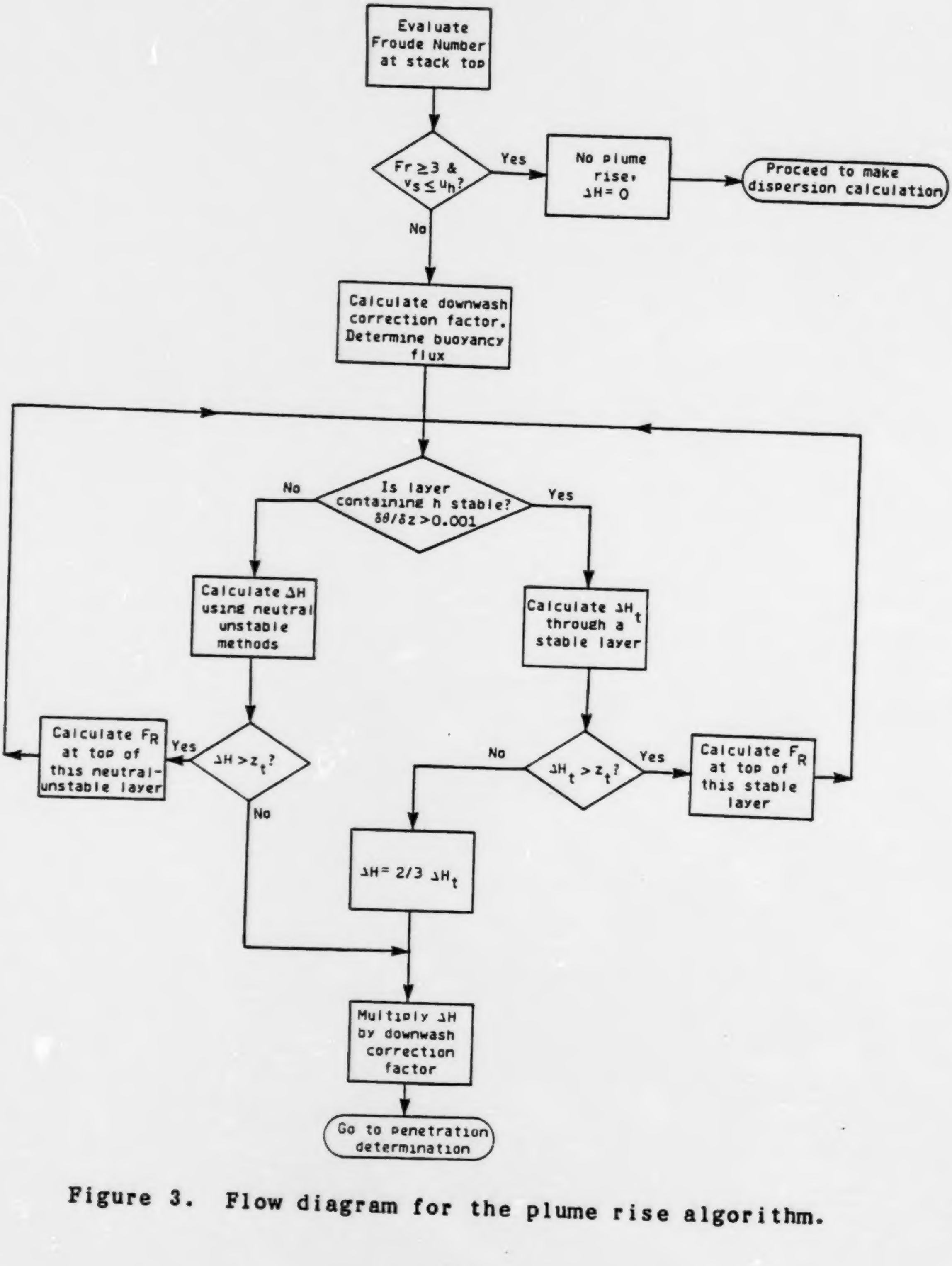

Evaluate Froude Number at stack top
Fr ≥ 3 & $v_s \leq u_h$?
Yes
No plume rise, ΔH = 0
Proceed to make dispersion calculation
No
Calculate downwash correction factor. Determine buoyancy flux
Is layer containing h stable? $\delta\theta/\delta z > 0.001$
No
Yes
Calculate ΔH using neutral unstable methods
Calculate ΔH_t through a stable layer
ΔH > z_t?
Yes
Calculate F_R at top of this neutral-unstable layer
No
$\Delta H_t > z_t$?
No
Yes
Calculate F_R at top of this stable layer
ΔH = 2/3 ΔH_t
Multiply ΔH by downwash correction factor
Go to penetration determination

Figure 3. Flow diagram for the plume rise algorithm.

Regardless of the thermal stability of the layer containing the stack, a value for the neutral-unstable momentum rise is needed. It is determined from

$$\Delta H_{um} = 3\ d\ v_s/u_h. \tag{9}$$

The subscript um is for unstable momentum. The initial buoyancy flux, F_o, is also required. For stacks of circular cross section,

$$F_o = g\ v_s\ d^2\ \Delta T/(4\ T_s), \tag{10}$$

where $\Delta T = T_s - T_h$ and T_h is the ambient air temperature at stack top.

The rate of potential temperature change with height for the layer containing the stack top is used to select the plume rise calculation method to be used initially. If $\delta\theta/\delta z$ is greater than 0.001 Km^{-1}, the layer is considered stable, and the stable plume rise methods are used (see page 26). Otherwise, neutral-unstable methods are used.

Plume Rise Calculation for Neutral-Unstable Conditions

For neutral-unstable conditions, buoyancy rise is calculated with two different equations and the lower value from these two is compared with the previously calculated momentum rise (Eq. 9). These equations were modified from techniques presented by Briggs (1983 and 1984). The two equations are

$$\Delta H = 30\ (F/u)^{0.6} + z_b \tag{11}$$

and

$$\Delta H = 24\ (F/u^3)^{0.6}\ [h + 200\ (F/u^3)]^{0.4} + z_b \tag{12}$$

Eq. 11 gives the lower value for low wind speeds, whereas Eq. 12 gives the lower value for high wind speeds. Both equations are evaluated and the lower value is used. For the initial evaluation at the stack top, $F = F_o$, h is the physical stack height, $u = u_h$, and z_b, the height of the base of the layer above stack top, is zero. The equation that produced the value selected is noted for use later. If the neutral-unstable momentum rise (previously calculated from Eq. 9) is higher than the value selected, momentum rise applies and the final plume rise is the value from Eq. 9. Since momentum rise takes place near the stack top, the distance to final rise is set equal to zero.

If the buoyancy rise is higher than the momentum rise, buoyancy rise applies. If the plume rise is below the top of the layer containing the stack, the calculated value is the final plume rise. However, if the plume rise is greater than the top of the layer considered, the procedures in this sub-section are reapplied, using the mean wind speed between stack top and the top of the layer instead of the wind speed at the stack top. If the rise still exceeds the top of this layer, then the subsequent residual buoyancy is calculated (see next sub-section).

Residual Buoyancy Calculation for Neutral-Unstable Conditions

If the buoyancy plume rise is higher than the layer under consideration, the residual buoyancy at the top of this layer is computed. The residual buoyancy F_R is that buoyancy at the top of the layer that will give the same plume height as previously calculated. For example, the buoyant plume rise from a 60 m stack is calculated to be 330 m and the top of the layer containing the stack top is 80 m above the stack top. The residual buoyancy at this level 80 m above the stack is that required to yield 250 m plume rise. If Eq. 11 determined the buoyant plume rise, then

$$F_R = u\ [(\Delta H - z_t)/30]^{5/3} \tag{13}$$

is used to determine the residual buoyancy, where z_t is the height of the top of the layer above stack top. If the layer considered is the one containing the stack, u is the mean wind speed between the stack top and the top of the layer. If the layer is a higher layer, u is the mean wind speed through that higher layer. If Eq. 12 was used, then the residual buoyancy is determined from

$$F_R = 0.0055\ m\ u^3/[1 + (h/m)]^{2/3}, \qquad (14)$$

where $m = \Delta H - z_t$. Here, also, if the layer considered is the one containing the stack, the mean wind speed between stack top and the top of the layer is used for u. However, if the layer is a higher layer, the mean wind speed through the higher layer is used.

Plume Rise Calculation for Neutral-Unstable Layers Above the Stack

After computing residual buoyancy at the layer top, thermal stability is determined for the next layer. If $\delta\theta/\delta z$ is greater than 0.001 Km^{-1}, then the layer is considered stable. Otherwise, the layer is considered neutral-unstable and Eqs. 11 and 12 are both evaluated using $F = F_R$, the mean wind speed for the layer, and the proper value for z_b. The lower plume rise value is used and compared with the top of the current layer, z_t. If plume rise terminates in this layer or if this is the last level for which data were furnished, then final plume rise has been found. If not, the iterative process described in the previous subsection is repeated until the final plume rise is obtained. For heights above the last data level, wind speeds are assumed constant and equal to that of the top data level and $\delta\theta/\delta z$ is assumed to be the same as the topmost layer.

Plume Rise Calculation for Stable Layers

For determination of plume rise through stable layers, the equation for stable momentum rise,

$$\Delta H_{sm} = 0.646\ [v_s^2\ d^2/(T_s\ u_h)]^{1/3}\ T^{1/2}/((\delta\theta/\delta z)^{1/6} \qquad (15)$$

is first evaluated. The subscript sm is for stable momentum. This value is compared with the buoyancy momentum rise (Eq. 9), and the lower of these two values is set aside as representing the momentum rise under stable conditions.

Stable buoyancy rise is evaluated using

$$\Delta H_t = [(1.8\ F_b\ T/(u\ \delta\theta/\delta z)) + z_b{}^3]^{1/3} \qquad (16)$$

where ΔH_t is the height above h of the plume top. For the layer containing the stack, $F_b = F_o$, T is the ambient air temperature at the level of the stack top, u is the stack top wind speed, and z_b is zero. This equation may give excessively high values for low wind speeds. Thus stable rise for calm conditions, as given by

$$\Delta H_t = [(4.1\ F_b\ T/(F_o{}^{1/3}\ \delta\theta/\delta z)) + z_b{}^{8/3}]^{3/8} \qquad (17)$$

is also evaluated and the lowest value used. The equation used is also noted. Assuming a "top hat" plume with the plume thickness equal to the rise, the plume rise and the plume centerline are 2/3 ΔH_t, and the height of the plume bottom is 1/3 ΔH_t. The plume rise is compared with the value selected for momentum rise. If the momentum rise is higher, momentum rise is used for the final plume rise. If the buoyancy rise is higher, the plume top is compared with the height of the top of the layer being considered. If it exceeds the top of the layer, then Eqs. 16 and 17 are re-evaluated, using mean values between the physical stack height (h) and the top of the layer for air temperature (T) and wind speed (u). If the resulting plume top is below the top of the layer, the final plume top height has been found. However, if the plume top still exceeds the top of the layer, the stable residual buoyancy must be determined.

For the situation of a stable layer above the one containing the stack, F_b is the residual buoyancy at the bottom of this layer, that is, the residual buoyancy at the top of the previous layer; T is the mean temperature of the layer; u is the mean wind speed of the layer; and z_b is the height above h of the base of the layer under consideration.

Residual Buoyancy Calculation for Stable Conditions

If Eq. 16 is used for the plume top determination, then

$$F_R = F_b - (0.56 \; \delta\theta/\delta z \; u/T) \; (z_t^3 - z_b^3) \tag{18}$$

is used to calculate the residual buoyancy at the top of a stable layer. If the layer considered is the one containing the stack, F_b is F_o, u and T are the mean wind speed and mean temperature between stack top and the top of the layer, and z_b is zero. If it is a higher layer, F_b is the residual buoyancy at the bottom of the layer, that is, the top of the previous layer; u and T are the mean wind speed and temperature for the layer; and z_t and z_b are the heights of the top and bottom, respectively, of the layer.

If the value from Eq. 17 is used to estimate plume rise, then

$$F_R = F_b - (0.24 \; \delta\theta/\delta z \; F_o^{1/3}/T) \; (z_t^{8/3} - z_b^{8/3}) \tag{19}$$

is used to calculate the residual buoyancy at the top of the layer.

Final Plume Rise

The calculation of plume rise continues layer by layer (see Figure 3) using appropriate equations for stable or neutral-unstable layers until the plume rise height remains within a given layer. This is then taken as the final plume rise.

PLUME PENETRATION ABOVE THE MIXING HEIGHT

Methods have been suggested by Briggs (1975) and others (Weil and Brower, 1982) to consider partial penetration of the plume into the more stable layer above the mixing height. A modification of these methods is used in TUPOS.

To account for partial plume penetration, TUPOS uses the "top hat" distribution recommended by Briggs (1975). This assumes a uniform distribution of the plume with height about the centerline as shown in Figure 4. The plume depth is assumed to be the same as the rise of the centerline above the stack top.

With this simple picture of plume rise, the following situations are considered. If the plume bottom ($H_b = H - 0.5\Delta H$) is above the mixing height (i.e., $H_b > L$), the dispersion calculation is skipped and no impact of the plume at ground level is assumed. If the plume top ($H_t = H + 0.5\Delta H$) is below the mixing height (i.e., $H_t < L$), the entire plume is available for dispersion in the mixing layer. If the mixing height is between plume top and plume bottom, i.e.,

$$H_b < L < H_t,$$

partial penetration is considered; that is, only the plume beneath the mixing height is considered for dispersion. The following parameters are used for the portion of the plume remaining within the mixed layer:

$$Q' = Q[L - H_b]/\Delta H, \tag{20}$$

$$H' = [L + H_b]/2, \text{ and} \tag{21}$$

$$\Delta H' = H' - h, \tag{22}$$

where Q and Q' are the source strength of the original plume and the remaining plume (beneath the mixing height), respectively; H' and ΔH' are the height and plume rise of the remaining plume.

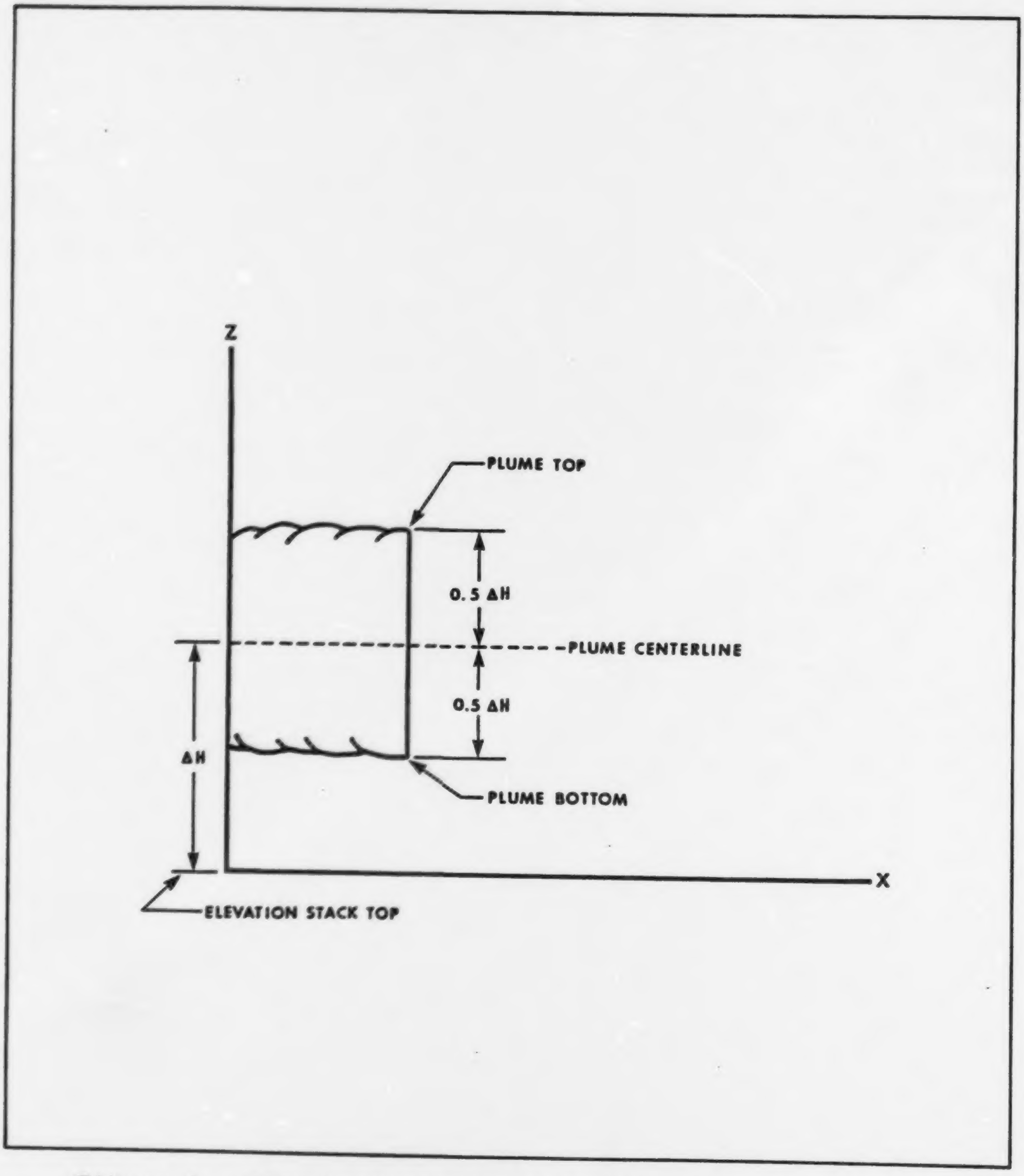

Z
PLUME TOP
0.5 ΔH
PLUME CENTERLINE
0.5 ΔH
ΔH
PLUME BOTTOM
X
ELEVATION STACK TOP

Figure 4. "Top hat" distribution for plume penetration.

Subsequently, $\Delta H'$ is used in calculating distance to final rise and buoyancy-induced dispersion. The plume penetration algorithm is summarized in Figure 5.

DISTANCE TO FINAL RISE

Except for the situation of the plume rise being due to momentum, in which case the distance to final rise is taken to be zero, the plume is assumed to rise to its final height using the 2/3 rule (Briggs, 1971, p. 1030). For any of the buoyant rise situations, the distance to final rise is calculated from

$$x_f = [u_h \ \Delta H'/(160\ F_o^{1/3})]^{1.5} \tag{23}$$

GRADUAL PLUME RISE

If the distance between the source and the receptor, x (in kilometers), is less than the distance to final rise, the equivalent of Briggs' (1971, p. 1030), Eq. 2 is used to determine plume height, that is,

$$H = h + (160\ F_o^{1/3}\ x^{2/3})/u_h. \tag{24}$$

Although gradual rise might be calculated layer-by-layer, the approximation in Eq. 24 using stack top conditions is sufficient. The results of this equation are used only to calculate the buoyancy-induced dispersion. Should it exceed the final rise for the appropriate condition, the final rise is substituted instead.

DISPERSION PARAMETERS

TUPOS uses hour-by-hour turbulence data, according to methods recommended by Irwin (1983), to determine the dispersion parameters. Irwin proposed characterizing σ_y and σ_z in a manner similar to Cramer (1976) and Draxler (1976). It was suggested that the standard deviations of the crosswind and vertical concentration

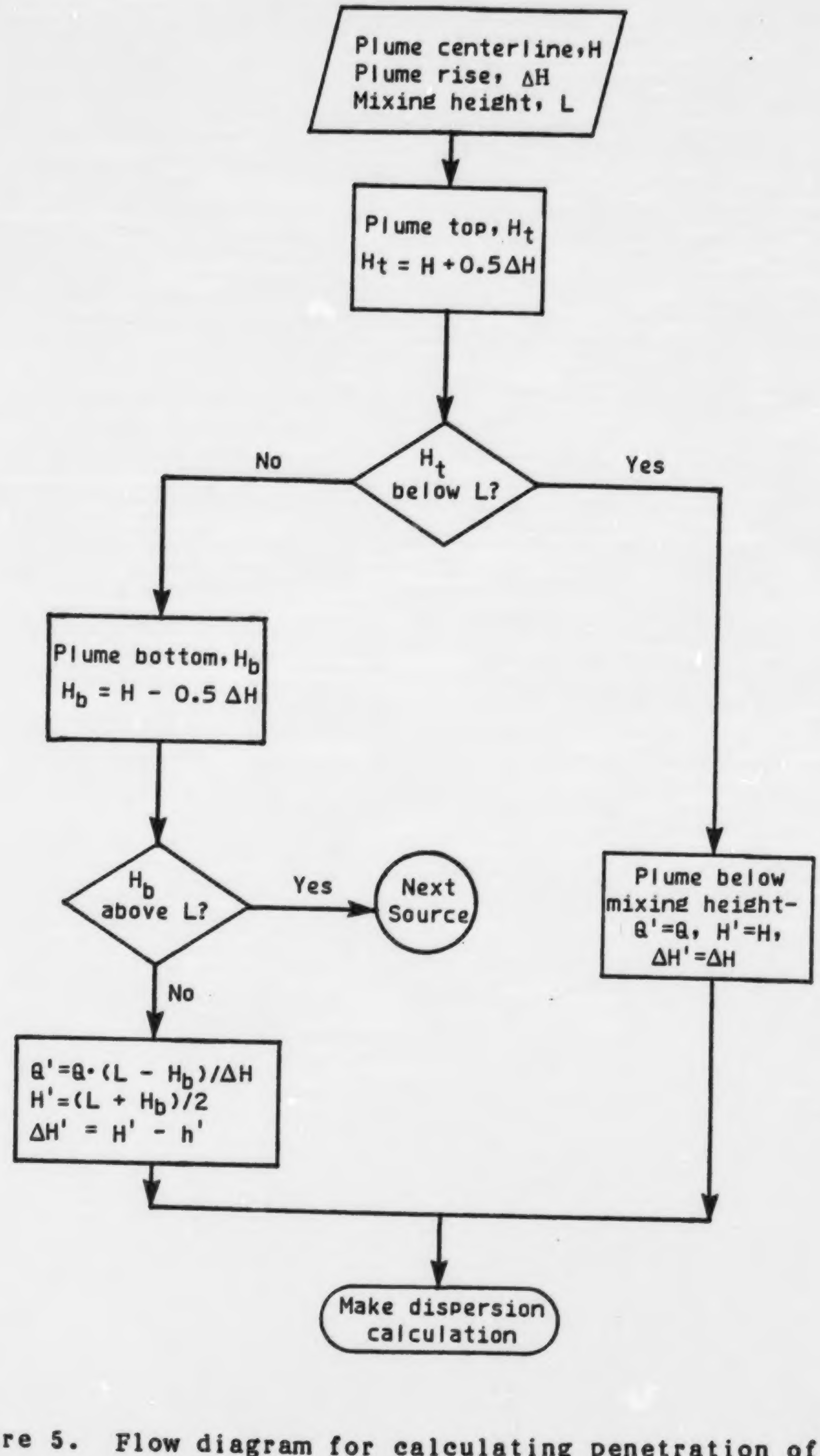

Plume centerline, H
Plume rise, ΔH
Mixing height, L
Plume top, Ht
Ht = H + 0.5ΔH
Ht below L?
No
Yes
Plume bottom, Hb
Hb = H - 0.5 ΔH
Hb above L?
Yes
Next Source
No
Q'=Q·(L - Hb)/ΔH
H'=(L + Hb)/2
ΔH' = H' - h'
Plume below mixing height-
Q'=Q, H'=H,
ΔH'=ΔH
Make dispersion calculation

Figure 5. Flow diagram for calculating penetration of plume in relation to mixing height.

distributions, σ_y and σ_z be viewed as:

$$\sigma_y = \sigma_v \, t \, f_y \tag{25}$$

and

$$\sigma_z = \sigma_w \, t \, f_z, \tag{26}$$

where σ_v and σ_w are the standard deviations of the horizontal and vertical components of the wind, t is the downstream travel time of the pollutant, and f_y and f_z are nondimensional functions of travel time.

For small angles, the following approximations are made:

$$\sigma_v = \sigma_a \, u, \tag{27}$$

$$\sigma_w = \sigma_e \, u, \tag{28}$$

where σ_a and σ_e are the standard deviation of horizontal (azimuth) and vertical (elevation) wind angles (in radians), respectively. Substituting Eqs. 27 and 28 and $t = x/u$ into Eqs. 25 and 26 yields,

$$\sigma_y = \sigma_a \, x \, f_y \qquad (29$$

and

$$\sigma_z = \sigma_e \, x \, f_z. \tag{30}$$

Irwin (1983) summarized the performance of various characteristics of f_y and f_z over a variety of conditions and recommended the following expression:

$$f_y, \, f_z = 1/[1 + 0.9(t/t_o)^{1/2}], \tag{31}$$

For f_y, $t_o = 1000$ seconds for all stability conditions. For f_z, $t_o = 500$ seconds for unstable and daytime neutral conditions, and $t_o = 50$ seconds for stable and nighttime neutral conditions.

OTHER CONSIDERATIONS

Removal or Chemical Reactions

Transformations of a pollutant resulting in its loss throughout the entire depth of each plume can be accomplished by an exponential decrease with travel time. The input parameter is the length of time expected for loss of 50% (half-life) of the emitted pollutant. TUPOS does not have the capability to change this parameter value during a given run. If the loss to be simulated occurs throughout the whole plume, without dependence upon concentration, then the exponential loss may provide a reasonable simulation if the loss rate is realistic. However, if the loss mechanism is selective, the loss rate will not be adequately modeled. Selective loss mechanisms include impaction with features on the ground surface, reactions with materials on the ground, or dependence on the concentration in a given small parcel of air (requiring consideration of contributions from all sources to this parcel). Simulation of dry deposition by exponential decay is quite reasonable if the plume is pretty well mixed vertically (unstable conditions), so that material is removed from the entire depth of the plume. When the plume is not well mixed, material deposits from the lowest layers of the plume and it becomes less Gaussian in shape with time.

Terrain Adjustments

A method is optionally included to treat terrain variations between source and receptor. For each source-receptor pair, two calculations are made and compared.

The first calculation is similiar to that in MPTER. The relation of the plume to the topography can be varied by the user according to stability category from a completely level plume (which does not respond at all to topographic changes) to a plume which responds completely to changes in the terrain (terrain following). Terrain adjustment factors are entered by the user for each of the four stability categories (unstable, daytime neutral, nighttime neutral, and stable). These factors can be any real number between 0 (represents plumes which level off and remain at the same mean-sea-level elevation) and 1 (represents plumes which completely respond to terrain). The author's current choice for these values is 0.5 for unstable and daytime neutral and 0.0 for nighttime neutral and stable conditions. (These values are used if both the terrain option and default option are employed.) Calculations are made by subtracting the adjusted difference, defined as the elevation of receptor ground level minus the elevation of the source ground level, from the effective plume height.

The equation used for the inclusion of the terrain adjustment is

$$H_A = H - (1 - F_T)\ \Delta E, \qquad (32)$$

where

H_A = adjusted effective height,
H = effective height,
$\Delta E = E_R - E_S$,
E_R = ground-level elevation of receptor,
E_S = ground-level elevation of source, and
F_T = terrain adjustment factor.

Shown below are the adjusted effective heights for four example values of the terrain factor:

$H_A = H$ for $F_T = 1$
$H_A = H - \Delta E$ for $F_T = 0$
$H_A = H - 0.7\ \Delta E$ for $F_T = 0.3$
$H_A = H - 0.1\ \Delta E$ for $F_T = 0.9$

The manner in which the terrain adjustment is simulated is depicted in Figure 6 for three values of the terrain adjustment factor.

The second calculation is made to insure that the concentration resulting from the first (terrain) calculation is not used if it exceeds the maximum concentration that is expected anywhere in the plume at this distance from the source without terrain. The calculation uses the fact that the concentration in an elevated plume is a maximum at the effective stack height until sufficient growth occurs so that significant eddy reflection results from a bounding surface (the ground or a stable layer aloft). The concentration maximum in the plume then shifts toward that surface with increased distance from the source. Once the maximum concentration reaches the bounding surface, it remains there with increasing downwind distances. The distance d_z, equal to H or L-H, whichever is smaller, is compared with the value of σ_z at this distance. If the ratio σ_z/d_z is less than or equal to 0.71, the concentration calculation is made with $z = H$, that is, plume level. If this ratio is 1.0 or greater, the calculation is made with $z = 0$. The following four equations (which were determined empirically) are used to approximate the transition zone when σ_z/d_z is between 0.71 and 1.0:

$r = 2.01428 - 1.42857\ (\sigma_z/d_z)$ for $0.71 < \sigma z/d_z \leq 0.85$; (33a)
$r = 2.925 - 2.5\ (\sigma_z/d_z)$ for $0.85 < \sigma_z/d_z \leq 0.93$; (33b)
$r = 5.25 - 5.0\ (\sigma_z/d_z)$ for $0.93 < \sigma_z/d_z \leq 0.97$; (33c)
$r = 13.3333 - 13.3333\ (\sigma_z/d_z)$ for $0.97 < \sigma_z/d_z < 1.00$. (33d)

The calculation is then made for $z = r\ d_z$.

The lower of the two calculations is taken as the value of the concentration for the terrain situation.

Buoyancy-Induced Dispersion

Emitted plumes undergo a certain amount of growth during the plume rise phase. This is due to the turbulent motions associated

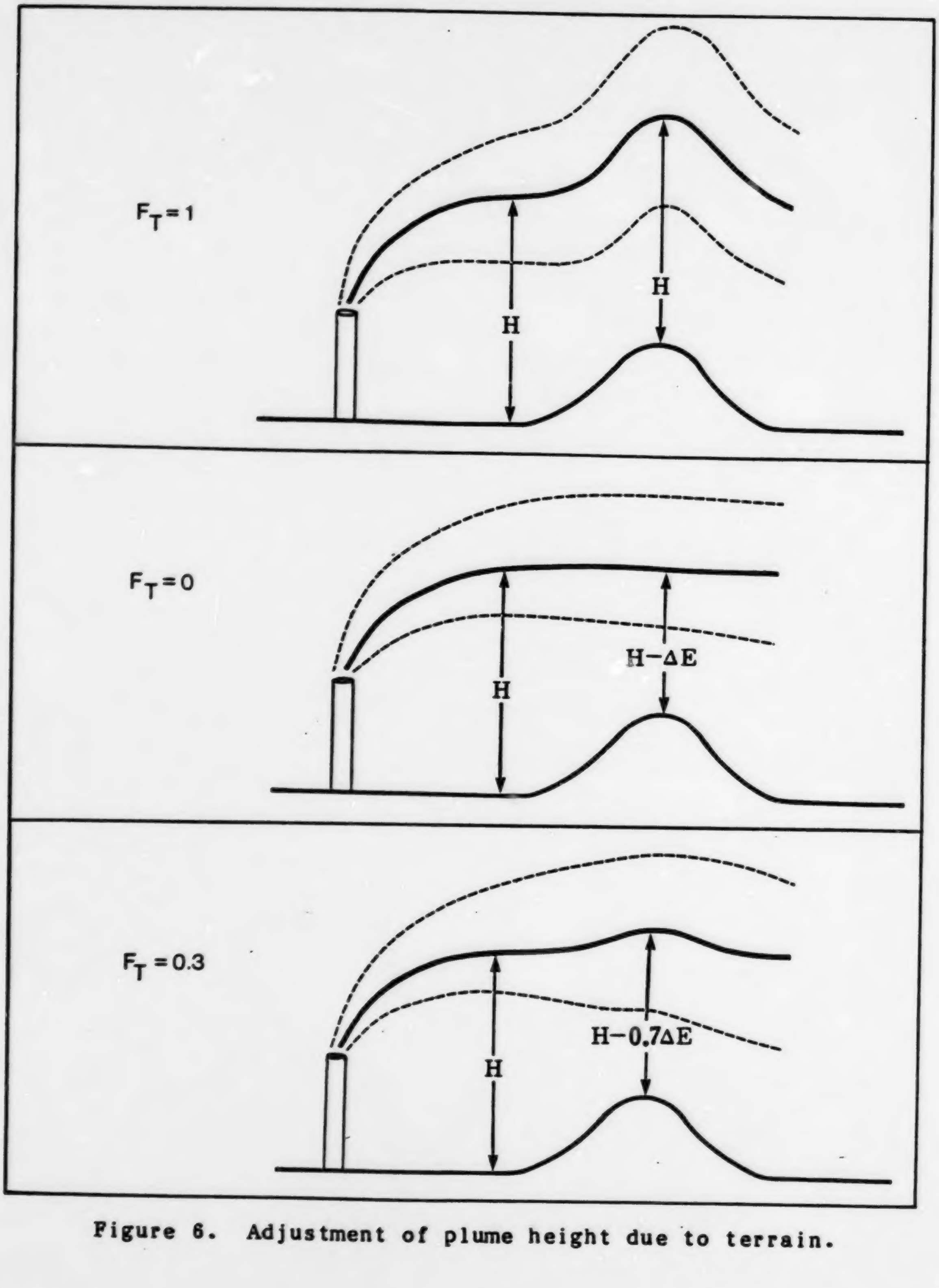

$F_T = 1$
H
H
$F_T = 0$
H
H−ΔE
$F_T = 0.3$
H
H−0.7ΔE

Figure 6. Adjustment of plume height due to terrain.

with conditions of plume release and the turbulent entrainment of ambient air. Pasquill (1976) suggests that this induced dispersion, σ_{zo}, can be approximated by $\Delta H/3.5$, and the effective dispersion can be determined by adding variances, i.e.,

$$\sigma_{ze} = \sqrt{\sigma_{zo}^2 + \sigma_z^2}, \tag{34}$$

where σ_{ze} is the effective dispersion and σ_z is the dispersion due to ambient turbulence levels. At the distance of final rise and beyond, σ_{zo} is a constant using ΔH of final rise. At distances closer to the source, the ΔH used to determine σ_{zo} is determined using the gradual rise formulation as follows:

$$\Delta H = 160\ F_o^{1/3}\ x^{2/3}/u_h, \tag{35}$$

where x is distance in km.

Since in the initial growth phases of release, the plume is nearly symmetrical about its centerline, buoyancy-induced dispersion in the horizontal direction is considered equal to that in the vertical, i.e., $\sigma_{yo} = \Delta H/3.5$. Although buoyancy-induced dispersion is normally employed by TUPOS, it is optional and may be omitted.

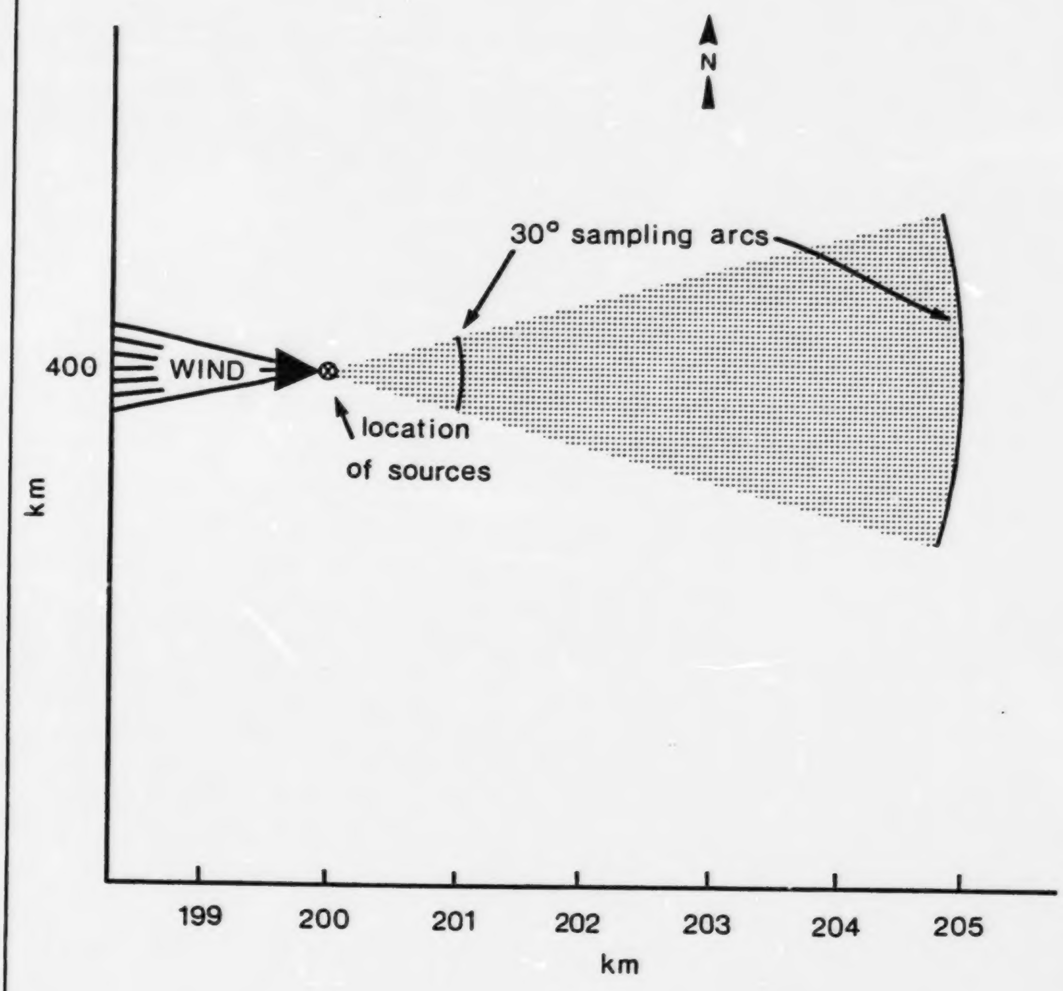
SECTION 6

EXAMPLE PROBLEM

In this section, a hypothetical problem is provided to illustrate the use of TUPOS and the type of information it provides. Details concerning input and output for this example are discussed in Section 9 after the reader has become familiar with TUPOS input data preparation.

The problem is illustrated in Figure 7. All pertinent meteorological parameters are provided in Table 4. Sampling is to be performed along 30° arcs 1 and 5 kilometers downwind of the sources (see Figure 7). The point source emission inventory is summarized in Table 5.

This hypothetical problem forms the basis for the sample test discussed in Section 9. The input data and TUPOS generated output are provided there.



N
30° sampling arcs
400
WIND
location
of sources
km
199
200
201
202
203
204
205
km

Figure 7. Source/receptor geometry for the example problem.

TABLE 4. MULTI-LEVEL METEOROLOGICAL DATA FOR THE EXAMPLE PROBLEM

					Wind		σ_a	σ_e
Year	Day	Hour	Level (m)	Temp. (K)	Dir (deg)	Speed (m/s)	(radian)	
1983	365	15	50	293.5	263	2.30	0.219	0.134
			100	293.0	265	2.40	0.198	0.152
stability = 1			200	292.0	268	2.50	0.178	0.172
(daytime unstable)			1500*	285.5	270	4.50	0.132	0.248
			1600	287.5	272	7.00	0.130	0.251
			1800	286.5	273	8.00	0.128	0.256
1983	365	16	50	293.3	264	2.26	0.209	0.123
			100	293.0	266	2.40	0.189	0.134
stability = 1			200	293.0	268	2.50	0.164	0.142
(daytime unstable)			1500*	285.5	269	4.50	0.138	0.161
			1600	287.5	271	7.00	0.124	0.176
			1800	286.5	273	8.00	0.107	0.183
1983	365	17	50	293.1	265	2.23	0.197	0.112
			100	293.0	267	2.40	0.174	0.111
stability = 1			200	292.5	269	2.50	0.158	0.110
(daytime unstable)			1500*	285.5	271	4.50	0.142	0.108
			1600	287.5	272	7.00	0.118	0.107
			1800	286.5	273	8.00	0.094	0.106
1983	365	21	50	292.0	258	2.00	0.132	0.091
stability = 4			100*	292.0	262	2.20	0.111	0.078
(nighttime stable)			200	291.8	265	2.50	0.092	0.064
1983	365	22	50	291.5	256	1.90	0.119	0.082
			100	291.7	261	2.13	0.099	0.069
stability = 4			200	291.8	263	2.50	0.085	0.058
(nighttime stable)			1500*	285.5	270	4.50	0.055	0.047
			1600	287.5	272	7.00	0.048	0.041
			1800	286.5	275	8.00	0.046	0.041
1983	365	23	50	291.0	254	1.80	0.105	0.070
			100	291.3	260	2.06	0.085	0.061
stability = 4			200	291.7	263	2.50	0.070	0.053
(nighttime stable)			1500*	285.5	271	4.50	0.037	0.045
			1600	287.5	272	7.00	0.036	0.038
			1800	286.5	273	8.00	0.035	0.032
1984	1	02	50	289.8	256	1.50	0.079	0.052
			100	290.0	258	1.86	0.067	0.043
stability = 4			200	--	263	2.50	0.056	0.038
(nighttime stable)			1500*	--	272	4.50	0.049	0.036
			1600	287.5	271	7.00	0.038	0.031
			1800	286.5	270	8.00	0.027	0.026

(continued)

TABLE 4 (continued)

			Level	Temp.	Wind			
Year	Day	Hour	(m)	(K)	Dir (deg)	Speed (m/s)	σ_a	σ_e (radian)
1984	1	03	50	289.5	255	1.40	0.075	0.046
			100	289.7	258	1.80	0.066	0.039
stability = 4			200	291.5	264	2.50	0.050	0.035
(nighttime stable)			1500*	285.5	271	4.50	0.041	0.031
			1600	287.5	271	7.00	0.033	0.027
			1800	286.5	271	8.00	0.024	0.024
1984	1	04	50	289.2	254	1.32	0.069	0.041
			100	289.6	257	1.76	0.058	0.036
stability = 4			200	291.5	262	2.50	0.045	0.031
(nighttime stable)			1500*	285.5	269	4.50	0.032	0.026
			1600	287.5	270	7.00	0.027	0.022
			1800	286.5	272	8.00	0.021	0.020
1984	1	07	50	288.7	252	1.40	0.048	0.032
			100	289.5	258	1.80	0.039	0.028
stability = 3			200	291.5	265	2.50	0.032	0.024
(nighttime neutral)			1600*	286.5	271	7.00	0.017	0.016
			1800	290.5	273	8.00	0.016	0.015
			2000	289.5	276	9.00	0.016	0.015
1984	1	08	50	289.0	253	1.60	0.052	0.041
			100	289.6	260	1.90	0.043	0.038
stability = 3			200	291.5	266	2.50	0.035	0.032
(nighttime neutral)			1600*	285.5	270	7.00	0.026	0.023
			1800	289.5	272	8.00	0.024	0.018
			2000	288.5	274	9.00	0.022	0.017
1984	1	09	50	289.9	255	1.90	0.071	0.056
			100	290.0	262	2.10	0.061	0.048
stability = 2			200	291.5	267	2.50	0.050	0.041
(daytime neutral)			1600*	284.5	271	7.00	0.040	0.034
			1800	288.5	272	8.00	0.034	0.021
			2000	287.5	272	9.00	0.030	0.019
1984	1	14	50	294.7	264	2.30	0.205	0.129
			100	294.1	266	2.40	0.194	0.149
stability = 1			200	293.0	268	2.50	0.175	0.168
(daytime unstable)			1600*	279.0	269	5.00	0.132	0.228
			1800	283.0	271	8.00	0.130	0.234
			2000	282.0	270	9.00	0.127	0.241

* Indicates the location of the mixing height.

TABLE 5. POINT SOURCE EMISSION INVENTORY FOR THE EXAMPLE PROBLEM

Location			Emission rate	Stack parameters			
X (km)	Y (km)	Elev (m)	SO2 (g/s)	Hgt (m)	Temp (K)	Dia (m)	Vel (m/s)
200.00	399.97	0	700	75	455	3.0	16.0
199.95	400.00	0	2750	165	425	4.0	38.0
200.00	400.03	0	10000	335	425	13.0	16.0

SECTION 7

COMPUTER ASPECTS OF THE MODEL

The general framework of TUPOS is discussed in this section. It is intended to give the reader a general knowledge of the computer program, rather than a detailed description of each subroutine. The overall structure of the program, the general processing flow, and a brief description of each subroutine is given in this section. Also provided is the overall system flow, which includes TUPOS, the input and output media, data flow, and preprocessor and postprocessor programs.

SYSTEM FLOW

Figure 8 outlines the overall system flow. Note that TUPOS is one of three programs required in the system. The Meteorological Processor for Dispersion Analyses, MPDA-1 (1986) and subsequent versions can be used to prepare meteorological data for input to TUPOS using unit 9. TUPOS-P can be used to obtain a detailed concentration summary. Optional input consists of hourly emissions data which includes emission rate, stack gas temperature, and stack gas exit velocity. The hourly emission data are expected on FORTRAN unit 10 and may be either a tape or disk file. If hourly emission data are entered, there must be a record of emission data for each hour of the simulation. Optional output includes hourly partial concentrations to FORTRAN unit 14. Hourly concentrations are automatically saved on FORTRAN unit 12. Units 12 and 14 can be either tape or disk media.

The input/output units used by TUPOS are summarized in Table 6.

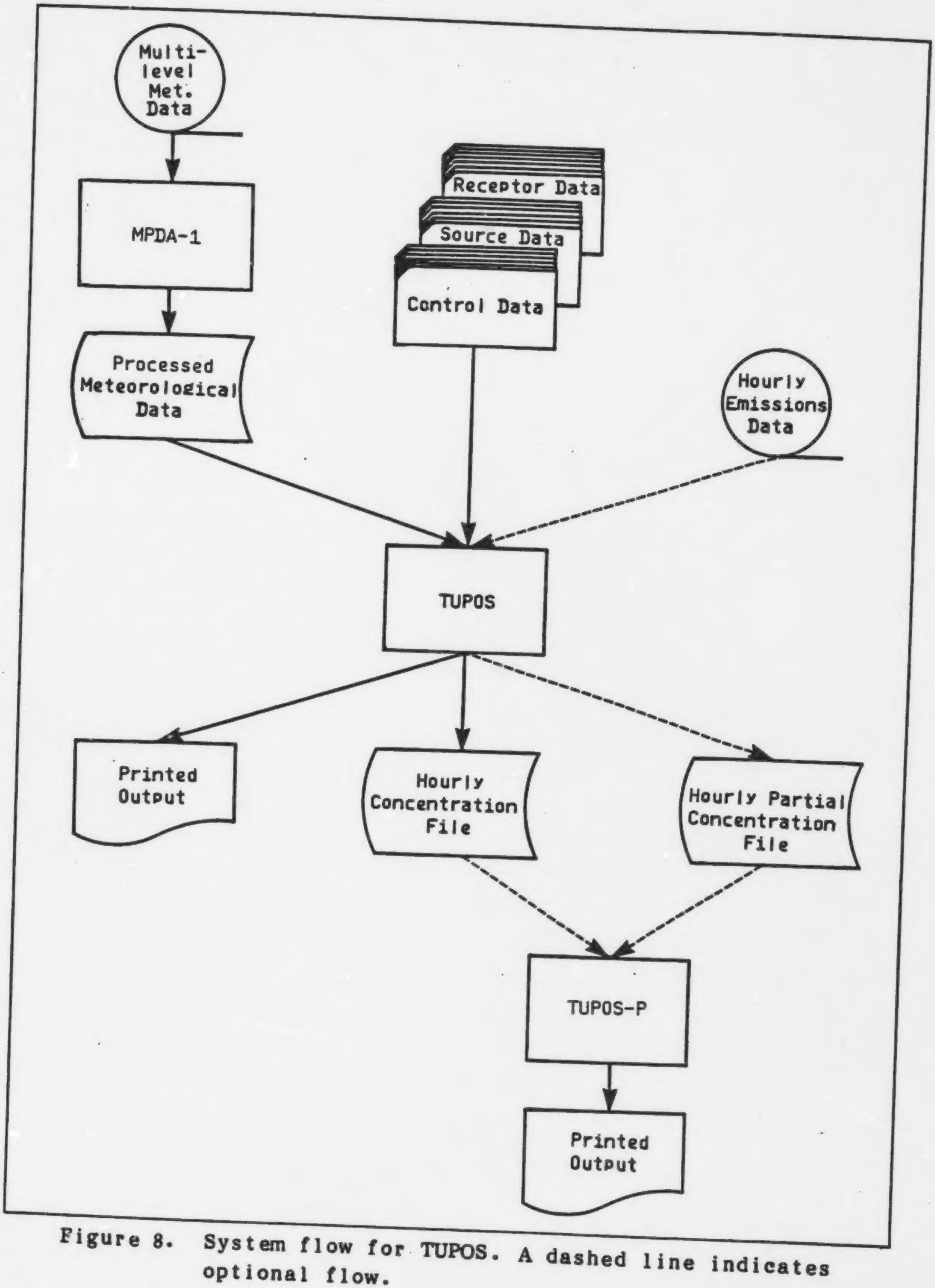

Multi-
level
Met.
Data
MPDA-1
Receptor Data
Source Data
Control Data
Processed
Meteorological
Data
Hourly
Emissions
Data
TUPOS
Printed
Output
Hourly
Concentration
File
Hourly Partial
Concentration
File
TUPOS-P
Printed
Output

Figure 8. System flow for TUPOS. A dashed line indicates optional flow.

TABLE 6. INPUT/OUTPUT UNITS USED BY TUPOS.

FORTRAN unit	Input/Output media	Mode	Contents
5	Reader or disk	Input	Program control and input data
6	Printer or disk	Output	Output listing
9	Tape or disk	Input	Sequential meteorology
10*	Tape or disk	Input	Hourly emissions data
12	Tape or disk	Output	Hourly concentrations
14*	Tape or disk	Output	Hourly partial concentrations

* Optional

STRUCTURE OF TUPOS

The program has a hierarchical static structure which also represents the dynamic structure as closely as possible. Thus, subprograms at higher levels perform coordinating tasks, and those at lower levels perform calculations; also, the order of subprograms at the same level represents the order of their execution. Subprograms are named according to the following convention:

TUlnn where TU represents TUPOS,
l is the level number, and
nn is the sequence number of the module on level l.

Figure 9 shows the program structure. Brief descriptions of the main program and subprograms follow.

TU100 -- This is the main program. It begins with introductory comments including the program abstract, authorship, and program structure. Following these introductory

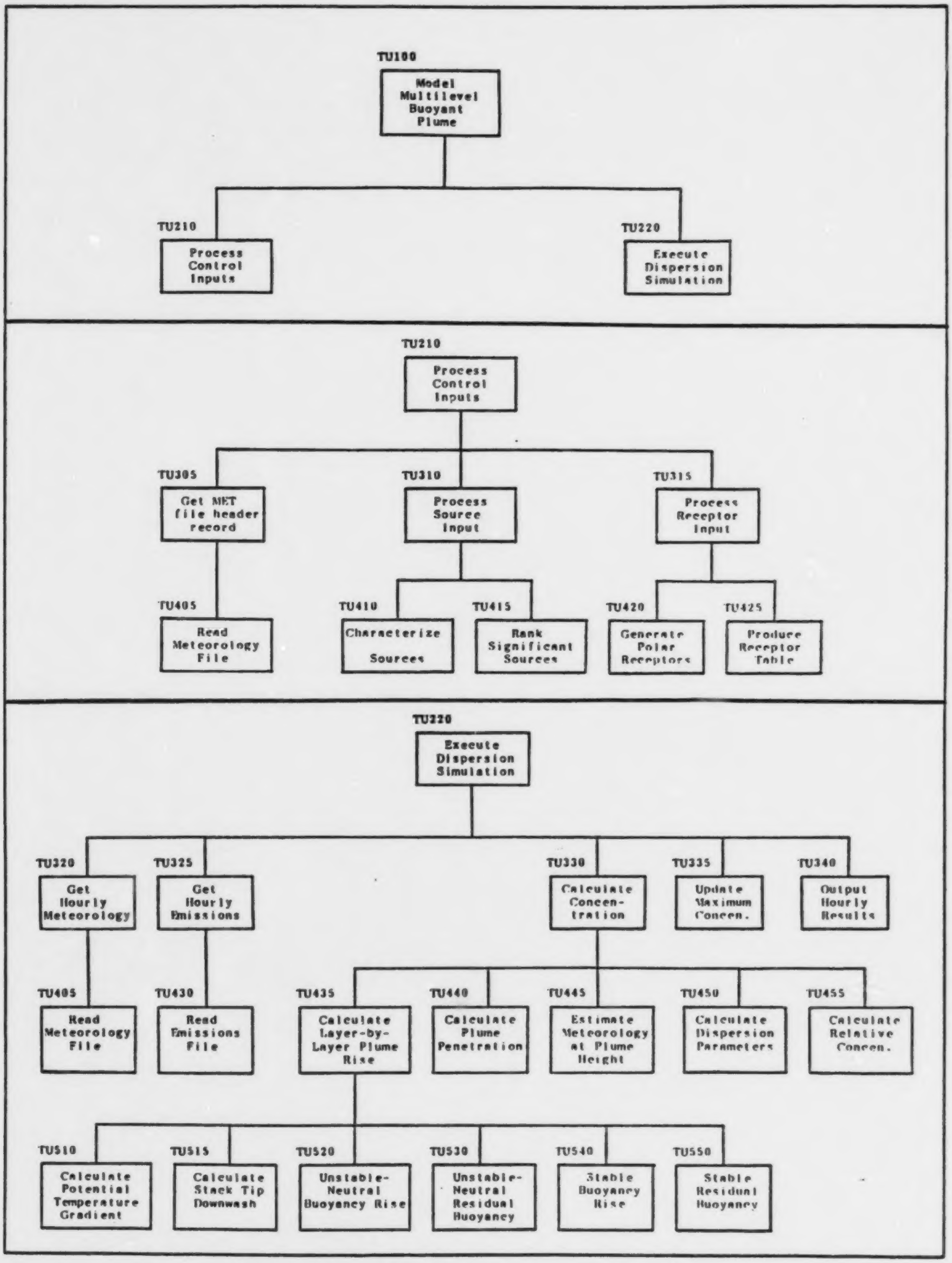

TU100
Model Multilevel Buoyant Plume
TU210
Process Control Inputs
TU220
Execute Dispersion Simulation
TU210
Process Control Inputs
TU305
Get MET file header record
TU310
Process Source Input
TU315
Process Receptor Input
TU405
Read Meteorology File
TU410
Characterize Sources
TU415
Rank Significant Sources
TU420
Generate Polar Receptors
TU425
Produce Receptor Table
TU220
Execute Dispersion Simulation
TU320
Get Hourly Meteorology
TU325
Get Hourly Emissions
TU330
Calculate Concen-tration
TU335
Update Maximum Concen.
TU340
Output Hourly Results
TU405
Read Meteorology File
TU430
Read Emissions File
TU435
Calculate Layer-by-Layer Plume Rise
TU440
Calculate Plume Penetration
TU445
Estimate Meteorology at Plume Height
TU450
Calculate Dispersion Parameters
TU455
Calculate Relative Concen.
TU510
Calculate Potential Temperature Gradient
TU515
Calculate Stack Tip Downwash
TU520
Unstable-Neutral Buoyancy Rise
TU530
Unstable-Neutral Residual Buoyancy
TU540
Stable Buoyancy Rise
TU550
Stable Residual Buoyancy

Figure 9. TUPOS program structure.

comments, subroutine TU210 is called to process the run control data. If the data are acceptable, subroutine TU220 is called to perform the run simulation. Program termination occurs exclusively in this subroutine.

TU210 -- Called by TU100, this module performs all input operations to unit 5 (control input file) and calls a number of subroutines (TU305, TU310, and TU315) to process the input. The subroutine begins with comments describing the control input file (unit 5).

TU220 -- This subroutine is called by TU100 and accomplishes the actual simulation. It includes the loop over hours. Comments describing the optional output files on units 12 and 14 are provided at the beginning of the subroutine.

TU305 -- This subroutine is called by TU210 and processes the header record of the sequential meteorology file (unit 9). TU305 calls subroutine TU405 to perform the actual I/O to the meteorology file.

TU310 -- Called by subroutine TU210, this subroutine coordinates all of the calculations related to source input. It calls subroutines TU410 and TU415 to characterize the point sources and rank significant sources, respectively. TU310 is executed once after all the source records have been read by subroutine TU210.

TU315 -- This subroutine is called by TU210 after all the receptor input has been read. It coordinates the generation of polar receptors and the printing of the receptor table by calling subroutines TU420 and TU425, respectively.

TU320 -- This subroutine is called by TU220 and gets the hourly meteorology for the current hour of simulation. TU320 calls subroutine TU405 to perform the actual I/O to the meteorology file.

TU325 -- This subroutine is called by TU220 if the hourly emissions option is exercised (i.e., IOPQ = 1). TU325 retrieves source data (emission rate, exit velocity, and stack gas temperature) for the current hour of simulation. TU325 calls subroutine TU430 to perform the actual I/O to the emissions file (unit 10).

TU330 -- Subroutine called by TU220 to calculate the point source contribution to each receptor. Subroutines TU435, TU440, TU445, TU450, and TU455 are called by TU330.

TU335 -- Subroutine called by TU220 to update the maximum hourly concentration.

TU340 -- This subroutine is called by TU220 to print hourly concentration results for the number of hours desired.

TU405 -- This subroutine, referenced by both TU305 and TU320, performs all input from the meteorology file (unit 9). It begins with comments describing the meteorology file.

TU410 -- Subroutine called by TU310 to characterize each point source based on estimates of potential impacts.

TU415 -- Subroutine called by TU310 to rank significant sources and print a table of ranked sources.

TU420 -- This subroutine is called by TU315 to generate a polar receptor grid in terms of cartesian coordinates.

TU425 -- This subroutine compiles and prints the receptor table which includes the receptor location, ground-level elevation, and height above ground level. It is called by TU315.

TU430 -- Subroutine called by TU325 to read the emissions file. It begins with comments describing the emissions file (unit 10).

TU435 -- Subroutine called by TU330 to perform layer-by-layer plume rise. This subroutine calls the following subroutines: TU510, TU515, TU520, TU530, TU540, and TU550.

TU440 -- Subroutine referenced by TU330 to calculate plume penetration through the mixing layer.

TU445 -- This subroutine is called by TU330 and estimates the meteorology at the plume level.

TU450 -- Subroutine called by TU330 to calculate the lateral and vertical dispersion parameters for a particular receptor.

TU455 -- Called by TU330 to compute the relative concentrations at a particular receptor.

TU510 -- Subroutine called by TU435 to calculate the potential temperature gradient between two adjacent layers.

TU515 -- Called by TU435 to compute the stack-tip downwash correction factor.

TU520 -- This module is called by TU435 to compute unstable-neutral buoyancy rise.

TU530 -- This subroutine is called by TU435 to calculate unstable-neutral residual buoyancy.

TU540 -- Module called by TU435 to compute stable buoyancy rise.

TU550 -- Subroutine called by TU435 to calculate stable residual buoyancy.

ZF -- This function calculates a normalized height of peak concentration and is referenced only by subroutine TU330.

CHRON -- This subroutine is referenced in several places (subroutines TU220, TU320, and TU325). It converts dates between 1960 and 1999 to a common sequential hour.

ICHRON -- Subroutine called by TU220 to convert a common sequential hour to a year, Julian day, and hour.

Figure 10 is an abbreviated flow diagram of TUPOS showing its major loops and the relationships of the subroutines to each other. Only the 300 and 400 level subroutines are shown in this diagram since they perform most of the calculations and processing.

NON-STANDARD FEATURES

The PARAMETER statement, which is used in the TUPOS source code, is considered a non-standard FORTRAN feature. It allows constants to be referenced by symbolic names. This facilitates the updating of programs in which the only changes between compilations are in the values of certain constants. In TUPOS, the PARAMETER statement initializes constants NLMAX, NPTMAX, and NREMAX (i.e.,the maximum number of vertical levels, point sources, and receptors, respectively). Also initialized by PARAMETER statements are the constants NDMAX and NRL. All these constants in turn are used to dimension numerous arrays. If the user's

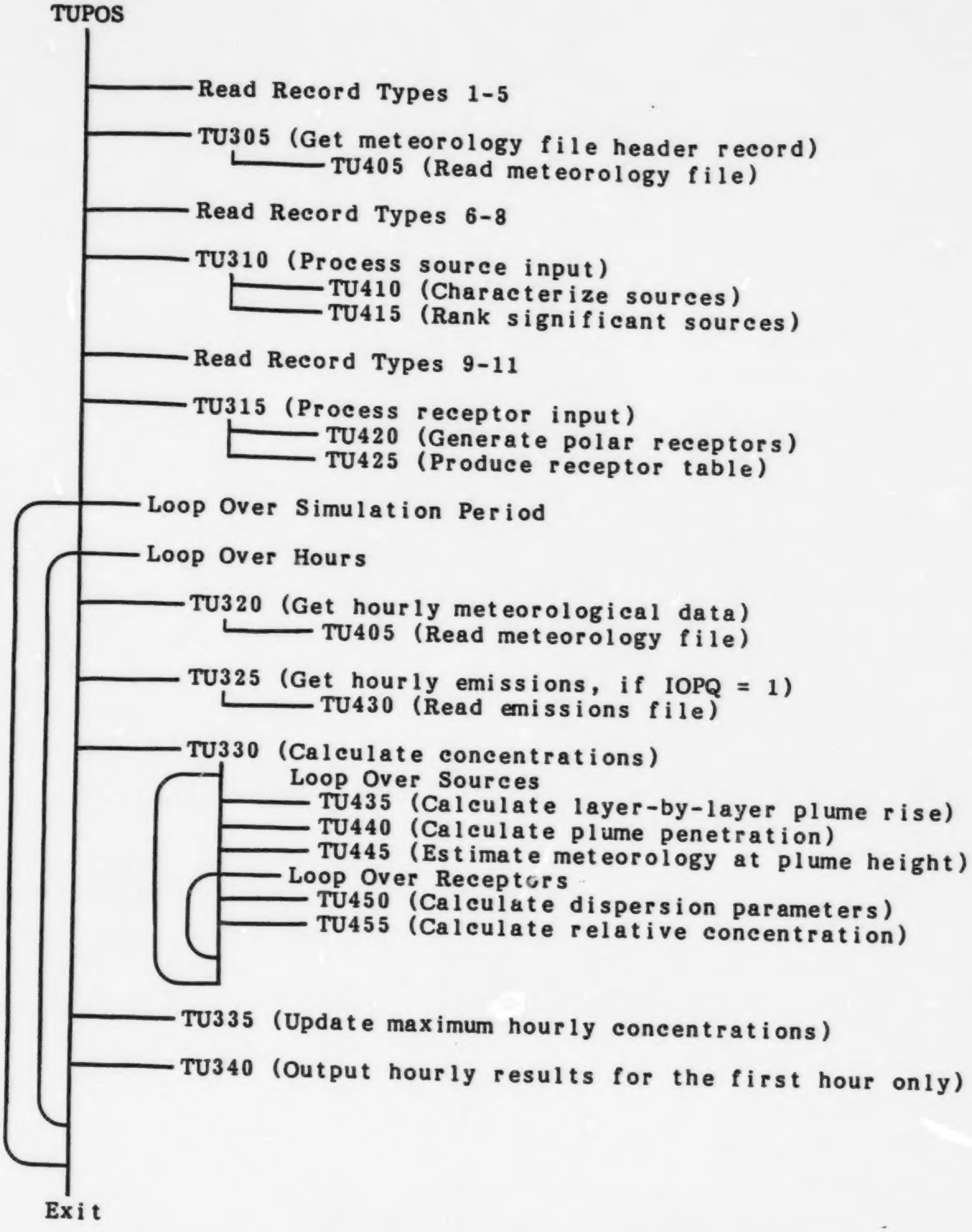

TUPOS
Read Record Types 1-5
TU305 (Get meteorology file header record)
TU405 (Read meteorology file)
Read Record Types 6-8
TU310 (Process source input)
TU410 (Characterize sources)
TU415 (Rank significant sources)
Read Record Types 9-11
TU315 (Process receptor input)
TU420 (Generate polar receptors)
TU425 (Produce receptor table)
Loop Over Simulation Period
Loop Over Hours
TU320 (Get hourly meteorological data)
TU405 (Read meteorology file)
TU325 (Get hourly emissions, if IOPQ = 1)
TU430 (Read emissions file)
TU330 (Calculate concentrations)
Loop Over Sources
TU435 (Calculate layer-by-layer plume rise)
TU440 (Calculate plume penetration)
TU445 (Estimate meteorology at plume height)
Loop Over Receptors
TU450 (Calculate dispersion parameters)
TU455 (Calculate relative concentration)
TU335 (Update maximum hourly concentrations)
TU340 (Output hourly results for the first hour only)
Exit

Figure 10. TUPOS Flow Diagram.

compiler does not support PARAMETER, the desired value of NLMAX, NPTMAX, NREMAX, NDMAX, and NRL must be hardcoded. The best way to do this is through global changes with an editor.

The ENCODE statement is also considered a non-standard FORTRAN feature. It is similar to formatted WRITE statements, however rather than transferring data between a peripheral unit and main storage, data is transferred between areas of main storage. In TUPOS, the ENCODE statement is used in labeling the polar coordinate receptors (subroutine TU420). If the user's compiler does not support ENCODE the code containing it should be eliminated. The result is that polar coordinate receptor names will be blank on output.

SECTION 8

INPUT DATA PREPARATION

RECORD INPUT SEQUENCE

There are 12 record types read by TUPOS; six of these are free format input. While the free format is simple to use, care should be taken to ensure that every variable is given a value in the correct order. Each variable should be separated by a comma and should conform to the variable name type. Three of the twelve record types are optional, depending on the options exercised on record type 5. A brief description of each input parameter is given in Table 7 with the appropriate units. The unit abbreviations are standard with the exception of "uu" and "uhu" which represent user length units and user height units, respectively. Under the "Format" column of Table 7, FF represents free format.

TABLE 7. RECORD INPUT SEQUENCE FOR TUPOS.

Record type & Variable	Column	Format	Variable description	Units
Record type 1				
LINE1	1-80	20A4	80-character title	--
Record type 2				
LINE2	1-80	20A4	80-character title	--

(continued)

TABLE 7 (continued)

Record type & Variable	Column	Format	Variable description	Units
Record type 3				
LINE3	1-80	20A4	80-character title	--
Record type 4				
IYRS	---	FF	2-digit year for this simulation	yr
IDYS	---	FF	Starting Julian day for this simulation (1-366)	day
IHRS	---	FF	Starting hour for this simulation (1-24)	hr
IHLIM	---	FF	Total number of hours to be simulated	hr
CONTWO	---	FF	Multiplier to convert user length units (uu)to kilometers i.e., ft to km 0.0003048 mi to km 1.609344 m to km 0.001	km/uu
CELM	---	FF	Multiplier to convert user height units (uhu) to meters, i.e., ft to m 0.3048	m/uhu
HAFL	---	FF	Pollutant half-life. An entry of 0.0 will cause no pollutant loss	sec
Record type 5				
NPOL	1- 4	A4	4-character pollutant name	
METID	5-12	2A4	8-character identifier Identical to METNAM in meteorological file	--

(continued)

TABLE 7 (continued)

Record type & Variable	Column	Format	Variable description	Units
MDATAC	13-18	I6	Month/day/year of data creation (6 digits) (Must be same as MDATA in meteorological file header record.)	--
MDATBC	19-24	I6	Hour/minute/second of data creation (6 digits) (Must be same as MDATB in meteorological file header record.)	--
Record type 6 -- Technical and external file options				
NPRNT	---	FF	Number of hours of printed output	--
	(1 = employ option: 0 = do not use option)			
IOPT	---	FF	Terrain adjustments	--
IOPB	---	FF	Buoyancy-induced dispersion	--
IOPD	---	FF	No stack downwash (use 0 to have downwash)	--
IOPG	---	FF	No gradual plume rise (use 0 to have gradual plume rise)	--
IOPM	---	FF	Check for plume within turbulent boundary layer (nighttime)	--
IDFLT	---	FF	Option for default values	
IOPQ	---	FF	Read hourly emissions (FORTRAN unit 10)	--
IOPR	---	FF	Input radial distances and generate polar coordinate receptors	--
IOPWPC	---	FF	Write partial concentrations to tape or disk (FORTRAN unit 14)	--

(continued)

TABLE 7 (continued)

Record type & Variable	Column	Format	Variable description	Units
Record type 7 -- Optional (read only if IOPT = 1)				
CONTER(1)	---	FF	Terrain adjustment factor for stability category 1	--
CONTER(2)	---	FF	Terrain adjustment factor for stability category 2	--
CONTER(3)	---	FF	Terrain adjustment factor for stability category 3	--
CONTER(4)	---	FF	Terrain adjustment factor for stability category 4	--
Record type 8 -- Point source information*				
PNAME	1-12	3A4	12-character source identification	--
QEAST	13-20	F8.2	East coordinate of source	uu
QNORD	21-28	F8.2	North coordinate of source	uu
QJ	29-36	F8.2	Emission rate for pollutant NPOL	g/sec
PSH	37-44	F8.2	Physical stack height	m
TS	45-52	F8.2	Stack gas temperature	K
D	53-60	F8.2	Stack top inside diameter	m
VS	61-68	F8.2	Stack gas exit velocity	m/sec
QELEV	69-72	F4.0	Stack base ground-level elevation	uhu

Important: A record containing 'ENDP' in the first 4 columns must follow the last source record.

(continued)

TABLE 7 (continued)

Record type & Variable	Column	Format	Variable description	Units
Record type 9 -- Optional (read only if IOPR = 1)				
CEST	---	FF	East coordinate of center of polar coordinate grid	uu
CNOR	---	FF	North coordinate of center of polar coordinate grid	uu
NAZ	---	FF	Number of azimuths	--
AZBEG	---	FF	Beginning azimuth (clockwise from north)	deg
AZINT	---	FF	Azimuth interval	deg
NRAD	---	FF	Number of radials	--
RADIL(1)	---	FF	First radial distance	uu
RADIL(2)	---	FF	Next radial distance	uu
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
RADIL(NRAD)	---	FF	Last radial distance	uu
Record type 10 -- Optional (read only if IOPT = 1 & IOPR = 1)				
ELR	---	FF	Polar coordinate receptor elevation. The elevations are ordered so elevations for the first radial distance are entered first, then elevations for each succeeding radial. There are NAZ times NRAD elevations.	uhu

(continued)

TABLE 7 (continued)

Record type & Variable	Column	Format	Variable description	Units
Record type 11 -- Receptor information (Both polar coordinate generated receptors and read-in receptors, this record, may be used provided that their total number does not exceed NREMAX set by the parameter statement.)				
RNAME	1- 8	2A4	8-character alphanumeric station identification	--
RREC	9-18	F10.3	East coordinate of receptor	uu
SREC	19-28	F10.3	North coordinate of receptor	uu
ZR	29-38	F10.0	Receptor height above local ground level	m
ELR	39-48	F10.0	Receptor ground-level elevation	uhu

Important: A record containing 'ENDR' in the first 4 columns must follow the last receptor record.

Record type & Variable	Column	Format	Variable description	Units
Record Type 12 -- Additional simulation period				
IYRS	---	FF	2-digit year for this simulation	yr
IDYS	---	FF	Starting Julian day for this simulation	day
IHRS	---	FF	Starting hour for this simulation	hr
IHLIM	---	FF	Total number of hours to be simulated	hr

* There are as many of this record type as there are sources.

INTRICACIES OF THE DATA

Most of the input data listed above are straightforward and typical of information required for Gaussian models. However, there are some input variables which require additional explanation to ensure proper assignment of values.

Record Type 4

The starting date must be within the period January 1, 1960 to December 31, 1999. Dates outside this range result in program termination. IYRS is a 2-digit year, that is, if the starting year is 1984 then IYRS = 84. IDYS is a Julian day between 1 and 366. IHRS is a 2-digit starting hour between 1 and 24.

Record Type 5

NPOL is a 4-character pollutant name for the pollutant whose dispersion is being simulated. METID, MDATAC, and MDATBC are compared with variables METNAM, MDATA, and MDATB, respectively, which are read from the first record of the meteorology file (FORTRAN unit 9). This is done to assure that the proper meteorological data is used for the simulation. If the variables do not match, then execution is terminated.

Record Type 6

To employ a particular option, a 1 is entered on input; otherwise a zero is entered. Some of the options are described briefly next.

IOPT -- Terrain adjustment is made if the option is employed. The use of this option requires input of source ground-level elevations on record type 8 and receptor ground-level elevations on record type 11. If polar coordinate receptors are generated (i.e., IOPR = 1), then record type 10 with elevations for the polar coordinate receptors is also read. Additionally, this option requires that four terrain adjustment factors, one for each stability category be entered on record type 7.

IOPD -- With IOPD = 0, stack downwash is used if applicable (see Section 5). With IOPD = 1, stack downwash is not estimated.

IOPG -- With IOPG = 0, gradual plume rise from stack top to the distance of final rise is determined using procedures outlined in Section 5.

IOPM -- With IOPM = 0, calculations are made in the usual way; IOPM = 1 represents a special case to save calculation time for elevated plumes during the nighttime. The purpose of this special case is so that if the simulation is only for extremely tall stacks, calculations can be avoided for nighttime situations when the plume can be expected to grow vertically very slowly and have no impact at the ground. With IOPM = 1 for nighttime conditions, if the plume bottom is below the height of the turbulent boundary layer (represented by the mixing height) the calculation is made in the usual way. However, if the plume bottom is above this height, this source is assumed not to contribute to receptor concentrations and no calculations of concentration are made.

IOPQ -- If IOPQ = 1, hourly emissions for each point source are read from unit 10 in subroutine TU430. A record with valid emissions must exit for each hour of the simulation.

IOPR -- For the user's convenience, implementing this option (IOPR = 1) provides a means of generating an array of receptors that are positioned about a specific source or some other point. If IOPR = 1, then the user must supply the necessary information on record type 9. If both IOPT = 1 and IOPR = 1, then elevations of the polar coordinate receptors must be given on record type 10. Receptor information may also be read in on record type 11 as well as generating polar coordinate receptors. The total number of receptors is restricted to that set by the parameter statement.

IOPWPC -- When IOPWPC = 1, an hourly partial concentration file is written to FORTRAN unit 14. Output can become quite lengthy since so much information is possible, as the contribution from each source to each receptor is written. Therefore, care should be taken to ensure the allocated storage space can accomodate the amount of data generated.

Record Type 7

If IOPT = 1, then four terrain adjustment factors, one for each stability category, should be entered on this record. The values must be real numbers between zero and one. Terrain adjustment factors outside this range result in program termination. See Section 5 for a description of the effects of the terrain adjustment factors. In general, the authors feel that the terrain adjustment factor should be 0.5 for unstable or daytime neutral conditions and 0.0 for stable or nighttime neutral conditions.

Record Type 8

The point source information is similar to that required by most dispersion models. If the option to enter hourly emission data is not used (i.e., IOPQ = 0), the emission data should be the best estimate to suit the purposes of the modeler. (May be average emissions; may be maximum possible emissions.) If the terrain adjustment option is employed (i.e., IOPT = 1), the ground-level elevation of each point source must be provided.

A record containing 'ENDP' in the first 4 columns must follow the last source record.

Record Type 9

By using the radial grid option, the user can construct a complete radial grid system or only a portion (i.e., sector) of it. Two examples of how this option might be used are provided in Figure 11.

Record Type 10

If IOPT = 1 and IOPR = 1, then TUPOS expects a record type 10. The elevations are ordered so that all elevations for the first radial distance are entered first, then all elevations for each succeeding radial. There should be NAZ times NRAD elevations.

Record Type 11

An additional method of entering receptors is to specify their locations on individual records for each receptor. Note that the receptor height above ground level must be in meters. In many applications the height may be zero, other situations may occur where determining concentrations above ground is desirable, such as at plume centerline. Although no restriction on this height exists, careful thought should be given to the assignment of receptor heights far removed from the ground surface.

Values for ELR are required only if the terrain adjustment option is employed (i.e., IOPT = 1). Note that elevations are entered in user height units. A receptor whose elevation is below the lowest stack base elevation or above the lowest stack top value is flagged in the receptor table.

A record containing 'ENDR' in the first 4 columns must follow the last receptor record. If no receptors are read in using card type 11, the record containing 'ENDR' must be read following the last record type 10 entry or record type 9 if record type 10 is not used.

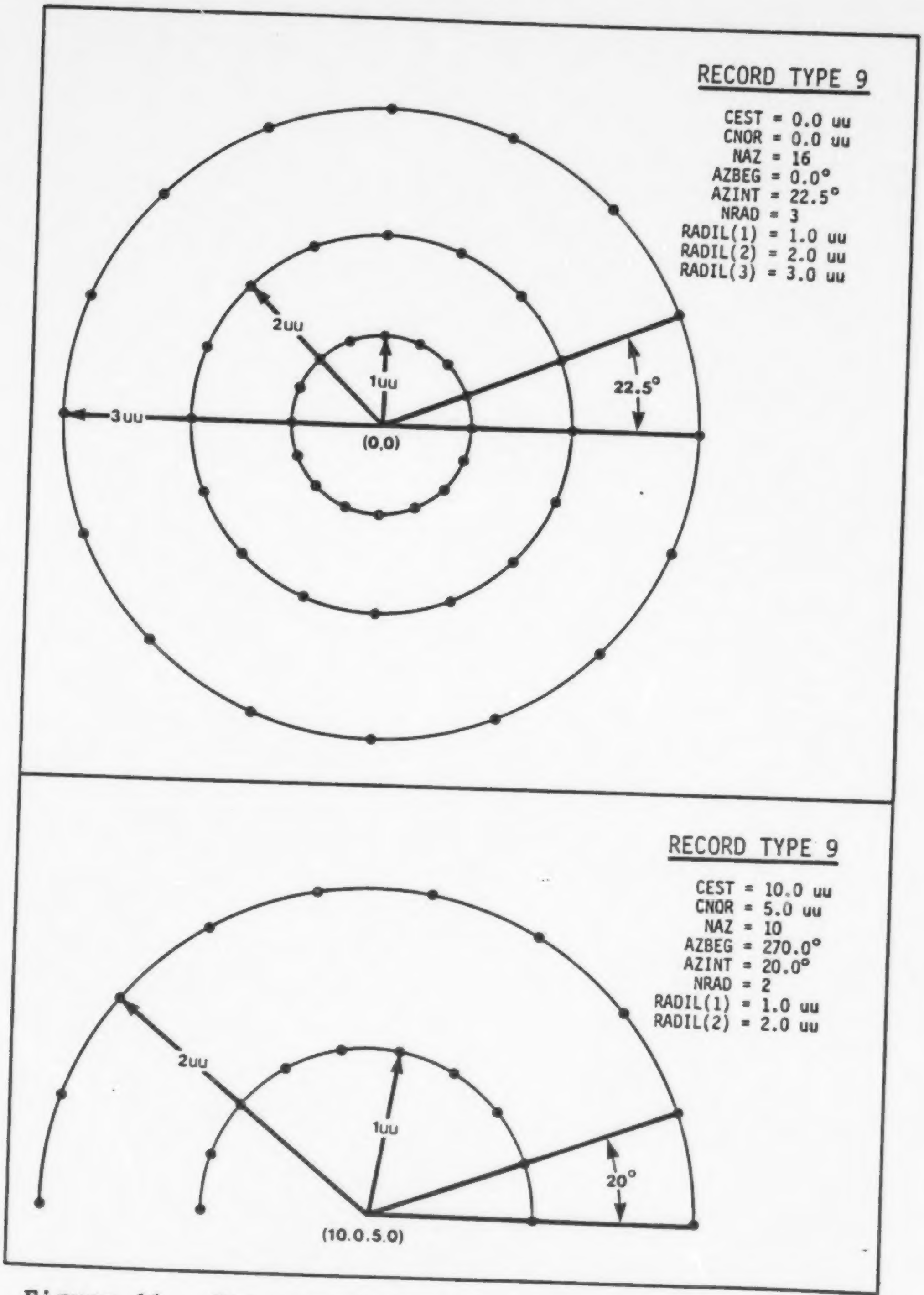

RECORD TYPE 9
CEST = 0.0 uu
CNOR = 0.0 uu
NAZ = 16
AZBEG = 0.0°
AZINT = 22.5°
NRAD = 3
RADIL(1) = 1.0 uu
RADIL(2) = 2.0 uu
RADIL(3) = 3.0 uu
2uu
1uu
3uu
22.5°
(0,0)
RECORD TYPE 9
CEST = 10.0 uu
CNOR = 5.0 uu
NAZ = 10
AZBEG = 270.0°
AZINT = 20.0°
NRAD = 2
RADIL(1) = 1.0 uu
RADIL(2) = 2.0 uu
2uu
1uu
20°
(10.0,5.0)

Figure 11. Two examples of the polar coordinate grid option.

Record Type 12

Additional time periods may be analyzed on a particular run by including one of these record types for each additional simulation period. It should be noted that all other control information remains fixed. An example might be helpful.

Suppose IYRS, IDYS, IHRS, and IHLIM on record type 4 are initialized as follows: 85, 1, 1, and 24. Thus the first simulation is for the first day of 1985. If the user also wants to analyze the 30th day of 1985, then a record type 12 must be included with the variables IYRS, IDYS, IHRS, and IHLIM on record type 12 defined as follows: 85, 30, 1, and 24. It is important to note that the additional simulation periods cannot go backward in time.

MULTI-LEVEL METEOROLOGICAL DATA FILE

It is recommended that the EPA-developed meteorological processor, MPDA-1 (1986), be used to generate the sequential meteorology file; however, information on the file layout is presented here for those users wishing to generate a TUPOS-compatible meteorology file. The file should be unformatted with the record layout shown in Table 8. The date in each record must be within the period January 1, 1960 to December 31, 1999.

TABLE 8. RECORD LAYOUT FOR THE METEOROLOGICAL DATA FILE

Variable	Description	Units
Record type 1 (occurs once at top of file)		
METNAM(2)	An 8 character alphanumeric identifier for the data	--
MDATA	Date-time of data creation (6 digits)	mo/day/yr
MDATB	Date-time of data creation (6 digits)	hr/min/sec
ND	Number of 72 character alphanumeric description records	--
DESC(18,ND)	ND lines of alphanumeric information that describe the file	--
Record type 2 (one for each hour)		
MYR	Year (2 digits)	yr
MJD	Julian day (3 digits)	day
MHR	Hour (2 digits)	hr
NLLIM	Number of data levels	--
LMX	Level number of mixing height	--
KLASS	Stability category (1 to 4)	--
ZL(NLLIM)	Height of each level	m
TL(NLLIM)	Temperature for each level	K
WDL(NLLIM)	Wind direction for each level	deg
UL(NLLIM)	Wind speed for each level	m/sec
SAL(NLLIM)	σ_a for each level	radians
SEL(NLLIM)	σ_e for each level	radians

OPTIONAL HOURLY EMISSION DATA FILE

If the hourly emissions option is employed (i.e., IOPQ = 1), TUPOS reads hourly values of emission rate, stack gas temperature, and stack gas exit velocity from FORTRAN unit 10. The emission file should be unformatted with the record layout shown in Table 9. The date in each record must be within the period January 1, 1960 to December 31, 1999. If IOPQ = 1 and the emission data for any hour in the simulation are missing, execution is terminated.

TABLE 9. RECORD LAYOUT FOR THE OPTIONAL HOURLY EMISSIONS FILE

Variable	Description	Units
Record type 1 (one for each hour)		
IQYR	2-digit year	yr
IQJD	Julian day	day
IQHR	2-digit hour	hr
QJ(NPTLIM)	Emission rate for the pollutant NPOL for each source NPT	g/sec
TS(NPTLIM)	Stack gas temperature for each source NPT	K
VS(NPTLIM)	Stack gas exit velocity for each source NPT	m/sec

SECTION 9

EXECUTION OF THE MODEL AND SAMPLE TEST

EXECUTION

TUPOS produces an error-free compile on UNIVAC EXEC 8 and IBM MVS computers. A sample job stream is presented below.

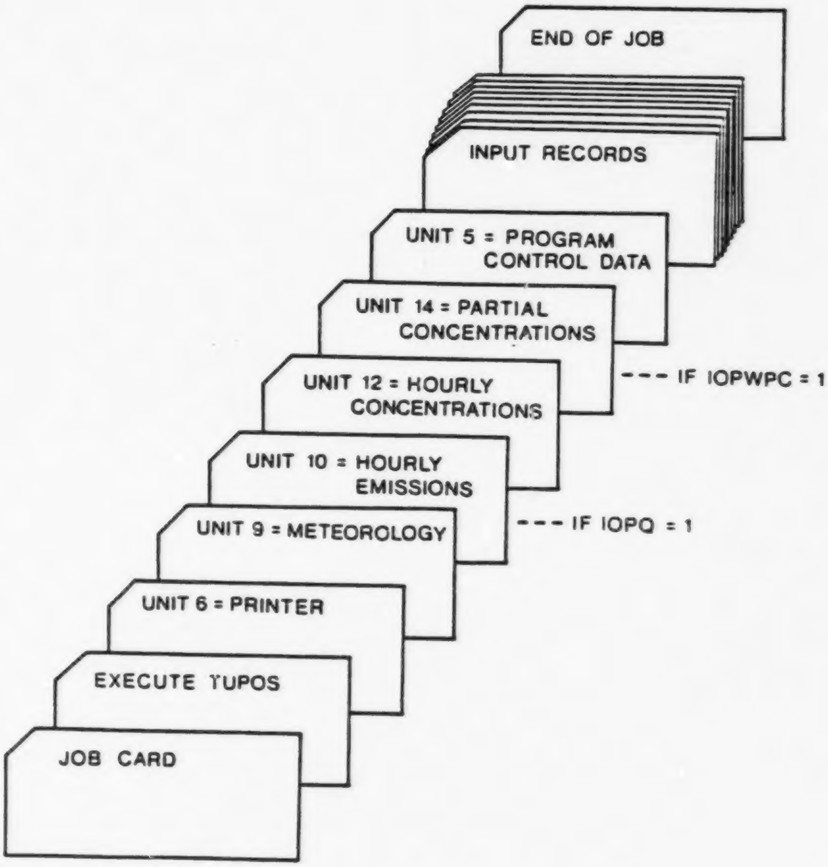

END OF JOB
INPUT RECORDS
UNIT 5 = PROGRAM CONTROL DATA
UNIT 14 = PARTIAL CONCENTRATIONS
--- IF IOPWPC = 1
UNIT 12 = HOURLY CONCENTRATIONS
UNIT 10 = HOURLY EMISSIONS
--- IF IOPQ = 1
UNIT 9 = METEOROLOGY
UNIT 6 = PRINTER
EXECUTE TUPOS
JOB CARD

Figure 12. Sample job stream for TUPOS.

A job stream for a UNIVAC EXEC 8 system might have the following form:

```
@RUN,R/R JOB-ID,ETC
@ASG,A MODELS*LOAD.
@ASG,A MET.
@USE 9,MET.
@ASG,A EMIS.
@USE 10,EMIS. }
              }  if IOPQ = 1
@ASG,R HCON.  }
@USE 12,HCON.
@ASG,R PCON.  }
              }  if IOPWPC = 1
@USE 14,PCON. }
@XQT MODELS*LOAD.TUPOS
(input records shown in Table 10)
@FIN
```

The following is a sample job stream for an IBM system under OS or MVS. Units 9, 10, 12, and 14 are assumed to have been preallocated.

```
//JOBID     JOB  (PROJ,ACCT,OTHER),CLASS=A,TIME=1
//XTUPOS    EXEC PGM=TUPOS,TIME=(,30)
//STEPLIB   DD   DSN=USER.MODELS.LOAD,DISP=SHR
//FT09F001  DD   DSN=USER.MET.DATA,DISP=SHR
//FT10F001  DD   DSN=USER.EMIS.DATA,DISP=SHR     if IOPQ = 1
//FT12F001  DD   DSN=USER.HCON.DATA,DISP=SHR
//FT14F001  DD   DSN=USER.PCON.DATA,DISP=SHR     if IOPWPC = 1
//FT06F001  DD   SYSOUT=A
//FT05F001  DD   *
(input records shown in Table 10)
/*
//
```

SAMPLE TEST

The example problem discussed in Section 6 is used for model verification. The meteorological file is generated by executing the auxiliary FORTRAN program, METVER, provided in Appendix B. The input data for model verification are given in Table 10. Annotated output for the example problem is shown in Figure 13. Users may verify the proper execution of the program by comparing their results with those given in the figure.

As listed in the Appendix, TUPOS requires just under 8,000 words of core storage for instructions and just under 20,000 words of core storage for data.

The relative potential impact given as part of the point source information is the emission over the square of the effective height for unstable conditions with a 3 m/s stack top wind speed.

TABLE 10. INPUT DATA FOR THE SAMPLE TEST

```
                                                                                   Record
Record                                                                              Type
Data column position
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

TUPOS TEST 9.                                                                         1
THREE SOURCES WITH BID.                                                               2
USES 24-HOUR SYNTHETIC DATA SET.                                                      3
83,365,15,24,1.,1.,0.                                                                 4
 SO2SET6    840210105523                                                              5
4,0,1,0,1,0,0,0,1,1                                                                   6
1 LOW         200.    399.97  700.     75.    455.      3.     16.    0.              8
2 MEDIUM      199.95  400.   2750.    165.    425.      4.     38.    0.              8
3 LARGE       200.    400.0310000.    335.    425.     13.     16.    0.              8
ENDP                                                                                  8
200.,400.,15,75.,2.,2,1.,5.                                                           9
ENDR                                                                                 11

Data column position
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

```
                 TUPOS-1.0 (VERSION 85091)
                 AN AIR QUALITY DISPERSION MODEL IN
                 SECTION 2. NON-GUIDELINE MODELS,
                 IN UNAMAP (VERSION 6) JUL 86.
                 SOURCE: UNAMAP FILE ON EPA'S UNIVAC 1110, RTP, NC.

TITLE:  TUPOS TEST 9.
        THREE SOURCES WITH BID.                     } Three line run title
        USES 24-HOUR SYNTHETIC DATA SET.

MET FILE IDENTIFIER:  SET6
CREATED:  840210 (YR MO DAY)     105523 (HR MIN SEC)
DESCRIPTION:  SYNTHETIC DATA SET WITH HOURS MISSING AND DATA MISSING.
              DATA AVAILABLE FOR HOURS 15,16,17,21,22,23,02,03,04,07,08,09, AND 14.    } Information regarding
              NO DATA FOR HOURS 18,19,20,24,01,05,06,10,11,12, AND 13.                  } meteorological file.
              HOUR 21 HAS ONLY 3 LEVELS.  SOME TEMPERATURES ARE MISSING FOR HOUR 02.
              VARIATION APPROXIMATES A CLEAR DAY AND NIGHT.

                       * * * GENERAL INPUT INFORMATION * * *

THIS SIMULATION FOR THE POLLUTANT  SO2 BEGINS AT YEAR: 1983   JULIAN DAY: 365   HOUR: 15 AND IS FOR   24 HOURS.
A FACTOR OF 1.000000+000 HAS BEEN SPECIFIED TO CONVERT USER LENGTH UNITS TO KILOMETERS.
THIS RUN WILL NOT CONSIDER ANY POLLUTANT LOSS.

OPTION SPECIFICATION (1 = EMPLOY OPTION; 0 = DO NOT USE OPTION.)
OPTION          MEANING
NPRNT     4     PRINT THIS MANY HOURS OF OUTPUT.

               TECHNICAL OPTIONS
IOPT      0    USE TERRAIN ADJUSTMENTS.
IOPB      1    USE BUOYANCY-INDUCED DISPERSION.
IOPD      0    NO STACK DOWNWASH.
IOPG      1    NO GRADUAL PLUME RISE.
IOPM      0    TEST AGAINST MIXING AT NIGHT.

               INPUT OPTIONS
IOPQ      0    READ HOURLY EMISSIONS ON UNIT 10.
IOPR      1    INPUT RADIAL DISTANCES AND GENERATE POLAR COORDINATE RECEPTORS.

               OUTPUT OPTIONS
IOPWPC    1    WRITE PARTIAL CONCENTRATIONS TO UNIT 14.
```

Figure 13. Annotated output for sample test.

```
TITLE:  TUPOS TEST 9.
        THREE SOURCES WITH BID.
        USES 24-HOUR SYNTHETIC DATA SET.
```

Run title included on every page of listing.

```
                                              * * * POINT SOURCE INFORMATION * * *

                  --------COORDINATES-------                        -------STACK PARAMETERS---------  REL POTEN     EFF      BUOY
  SOURCE              (USER UNITS)           ---EMISSIONS (G/SEC)---   HGT    TEMP     DIA     VEL     IMPACT      HGT      FLUX
#  NAME            EAST     NORTH      ELEV           SO2              (M)     (K)     (M)    (M/S)    Q/M**2      (M)   M**4/S**3
1 1 LOW           200.00   399.97       .00          700.00            75.00  455.00    3.00   16.00 5.48877-003  357.12   125.69
2 2 MEDIUM        199.95   400.00       .00         2750.00           165.00  425.00    4.00   38.00 4.49894-003  781.83   462.94
3 3 LARGE         200.00   400.03       .00        10000.00           335.00  425.00   13.00   16.00 2.93716-003 1845.17  2058.87

                                             * * * RANKED  SO2 POINT SOURCES * * *

                                             RANK    SOURCE        REL POTEN
                                                     NUMBER         IMPACT
                                               1        1           5488.77
                                               2        2           4498.94
                                               3        3           2937.16
```

Point sources ranked according to potential impact.

Figure 13. (continued)

```
TITLE:  TUPOS TEST 9.
        THREE SOURCES WITH BID.
        USES 24-HOUR SYNTHETIC DATA SET.

                       * * * RECEPTOR INFORMATION * * *

GENERATES   30 POLAR COORDINATE RECEPTORS CENTERED ABOUT (  200.000,  400.000).
    15 AZIMUTHS BEGINNING AT  75.0 DEGREES, AT INTERVALS OF   2.00 DEGREES.
     2 RADIAL DIST. (USER UNITS):   1.000   5.000

RECEPTOR    IDENTIFICATION        ------------COORDINATES------------     HEIGHT ABOVE
                                            (USER UNITS)                  LOCAL GRD-LVL
                                      EAST        NORTH        ELEV           (M)
    1            75. 1.0             200.97      400.26         .00           .00
    2            77. 1.0             200.97      400.22         .00           .00
    3            79. 1.0             200.98      400.19         .00           .00
    4            81. 1.0             200.99      400.16         .00           .00
    5            83. 1.0             200.99      400.12         .00           .00
    6            85. 1.0             201.00      400.09         .00           .00
    7            87. 1.0             201.00      400.05         .00           .00
    8            89. 1.0             201.00      400.02         .00           .00
    9            91. 1.0             201.00      399.98         .00           .00
   10            93. 1.0             201.00      399.95         .00           .00
   11            95. 1.0             201.00      399.91         .00           .00
   12            97. 1.0             200.99      399.88         .00           .00
   13            99. 1.0             200.99      399.84         .00           .00
   14           101. 1.0             200.98      399.81         .00           .00
   15           103. 1.0             200.97      399.78         .00           .00
   16            75. 5.0             204.83      401.29         .00           .00
   17            77. 5.0             204.87      401.12         .00           .00
   18            79. 5.0             204.91      400.95         .00           .00
   19            81. 5.0             204.94      400.78         .00           .00
   20            83. 5.0             204.96      400.61         .00           .00
   21            85. 5.0             204.98      400.44         .00           .00
   22            87. 5.0             204.99      400.26         .00           .00
   23            89. 5.0             205.00      400.09         .00           .00
   24            91. 5.0             205.00      399.91         .00           .00
   25            93. 5.0             204.99      399.74         .00           .00
   26            95. 5.0             204.98      399.56         .00           .00
   27            97. 5.0             204.96      399.39         .00           .00
   28            99. 5.0             204.94      399.22         .00           .00
   29           101. 5.0             204.91      399.05         .00           .00
   30           103. 5.0             204.87      398.88         .00           .00

NOTE:   THE TERRAIN OPTION, IOPT, IS NOT BEING USED FOR THIS RUN AND
        GROUND-LEVEL ELEVATIONS (STACK OR RECEPTOR) GIVEN ON INPUT ARE IGNORED.
```

If IOPR = 1, then details concerning TUPOS-generated radial grid are provided here.

Warning message regarding source and receptor elevations.

Radial receptors identified internally. First number indicates azimuth direction; second number is the distance from the center in user units. This column is blank if user's computer does not support the non-standard FORTRAN statement, ENCODE.

Figure 13. (continued)

```
TITLE:  TUPOS TEST 9.
        THREE SOURCES WITH BID.
        USES 24-HOUR SYNTHETIC DATA SET.

MET DATA FOR YEAR: 83  JUL DAY: 365  HOUR: 15  LMX = 4  KLASS = 1
LVL     HT   MIX        SA        SE        WD        U          T         DTHDZ
 6   1800.0           .1280     .2560     273.0     8.00     286.50
 5   1600.0           .1300     .2510     272.0     7.00     287.50      .0048
 4   1500.0   *       .1320     .2480     270.0     4.50     285.50      .0298
 3    200.0           .1760     .1720     268.0     2.50     292.00      .0048
 2    100.0           .1980     .1520     265.0     2.40     293.00     -.0002
 1     50.0           .2190     .1340     263.0     2.30     293.50     -.0002

                        1         2         3
FINAL HT (M)          177.7     322.7     627.1      4         5         6         7         8         9        10
DIST FIN HT (KM)        .165      .176      .241

                        * * *  SO2 CONCENTRATION TABLE FOR HOUR 83-365-15 * * *

RECEPTOR    IDENTIFICATION      ------------COORDINATES------------   HEIGHT ABOVE
                                         (USER UNITS)                  LOCAL GRD-LVL     CONCENTRATION
                                   EAST       NORTH        ELEV           (M)          (MICROGRAMS/M**3)    RANK
    1          75. 1.0           200.97      400.26         .00           .00               252.74          24
    2          77. 1.0           200.97      400.22         .00           .00               443.52          22
    3          79. 1.0           200.98      400.19         .00           .00               709.34          18
    4          81. 1.0           200.99      400.16         .00           .00              1036.70          16
    5          83. 1.0           200.99      400.12         .00           .00              1387.48          13
    6          85. 1.0           201.00      400.09         .00           .00              1703.16          10
    7          87. 1.0           201.00      400.05         .00           .00              1919.52           8
    8          89. 1.0           201.00      400.02         .00           .00              1987.33           7
    9          91. 1.0           201.00      399.98         .00           .00              1890.10           9
   10          93. 1.0           201.00      399.95         .00           .00              1650.74          11
   11          95. 1.0           201.00      399.91         .00           .00              1322.34          14
   12          97. 1.0           200.99      399.88         .00           .00               970.11          17
   13          99. 1.0           200.99      399.84         .00           .00               650.39          19
   14         101. 1.0           200.98      399.81         .00           .00               397.38          23
   15         103. 1.0           200.97      399.78         .00           .00               220.50          26
   16          75. 5.0           204.83      401.29         .00           .00                60.06          29
   17          77. 5.0           204.87      401.12         .00           .00               203.90          27
   18          79. 5.0           204.91      400.95         .00           .00               561.21          21
   19          81. 5.0           204.94      400.78         .00           .00              1258.50          15
   20          83. 5.0           204.96      400.61         .00           .00              2308.27           6
   21          85. 5.0           204.98      400.44         .00           .00              3472.68           4
   22          87. 5.0           204.99      400.26         .00           .00              4293.08           2
   23          89. 5.0           205.00      400.09         .00           .00              4364.74           1
   24          91. 5.0           205.00      399.91         .00           .00              3648.90           3
   25          93. 5.0           204.99      399.74         .00           .00              2505.38           5
   26          95. 5.0           204.98      399.56         .00           .00              1489.73          12
   27          97. 5.0           204.96      399.39         .00           .00               647.93          20
   28          99. 5.0           204.94      399.22         .00           .00               242.18          25
   29         101. 5.0           204.91      399.05         .00           .00                73.28          28
   30         103. 5.0           204.87      398.88         .00           .00                17.77          30
```

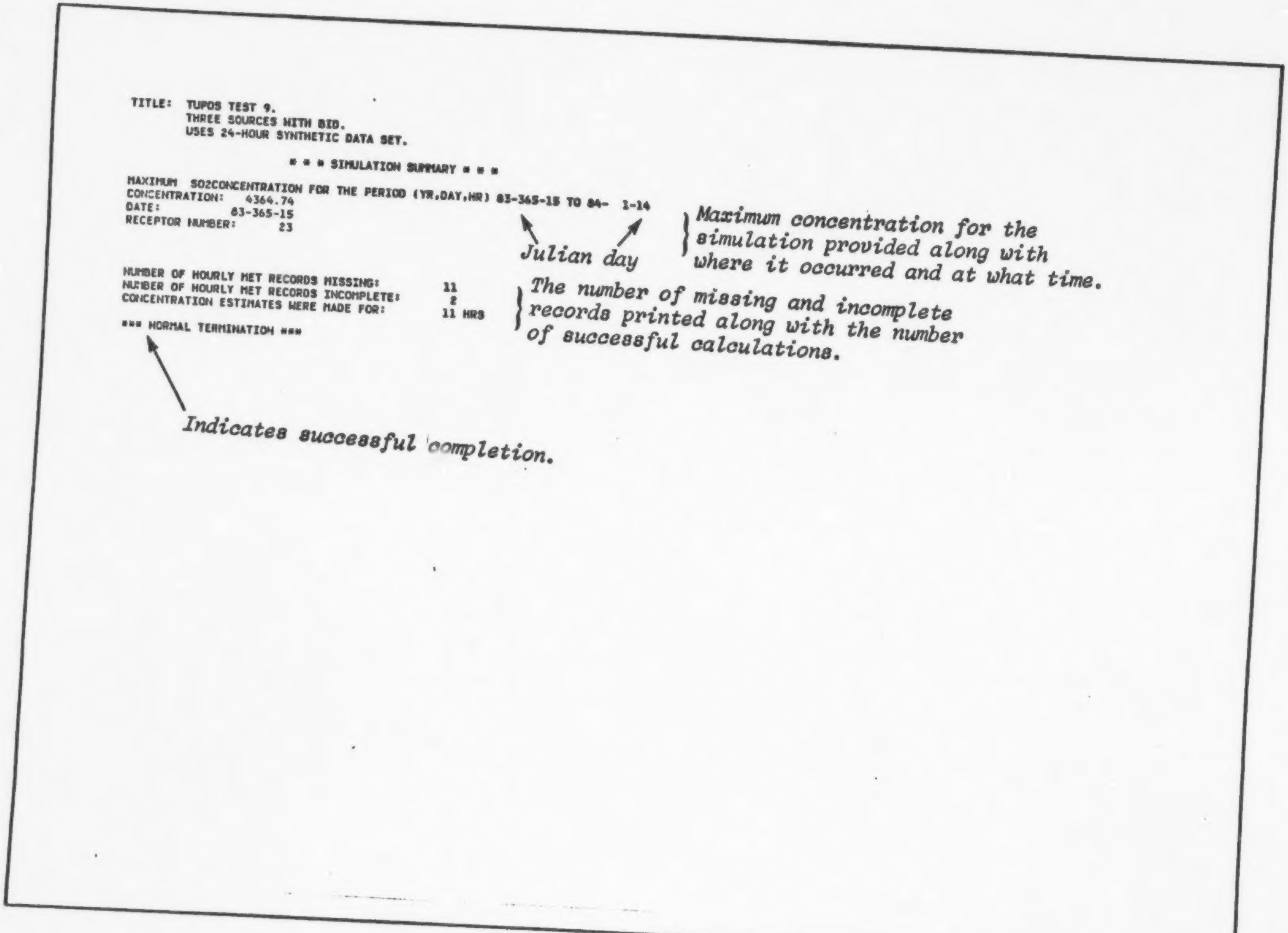
Final effective height and distance to final height by source.

Receptors ranked according to concentration (from highest to lowest concentration).

Output is abridged.

⋮

Figure 13. (continued)



```
TITLE:  TUPOS TEST 9.
        THREE SOURCES WITH BID.
        USES 24-HOUR SYNTHETIC DATA SET.

                  * * * SIMULATION SUMMARY * * *

MAXIMUM  SO2CONCENTRATION FOR THE PERIOD (YR,DAY,HR) 83-365-15 TO 84-  1-14
CONCENTRATION:   4364.74
DATE:          83-365-15
RECEPTOR NUMBER:      23


NUMBER OF HOURLY MET RECORDS MISSING:          11
NUMBER OF HOURLY MET RECORDS INCOMPLETE:        2
CONCENTRATION ESTIMATES WERE MADE FOR:         11 HRS

*** NORMAL TERMINATION ***
```

Julian day

Maximum concentration for the simulation provided along with where it occurred and at what time.

The number of missing and incomplete records printed along with the number of successful calculations.

Indicates successful completion.

Figure 13. (continued)

CONCENTRATION FILES

As mentioned earlier, the principal output consists of tape or disk files. An hourly concentration file is automatically created by TUPOS; the user has the option of creating a partial concentration file. Hourly concentrations are written to FORTRAN unit 12 and hourly partial concentrations to unit 14. The user is encouraged to use the EPA-developed postprocessor, TUPOS-P (Turner et al., 1986), to analyze the hourly and partial concentration files. However, the record layouts for both unformatted files are provided in Tables 11 and 12.

TABLE 11. RECORD LAYOUT FOR THE HOURLY CONCENTRATION FILE

Variable	Description	Units
Record type 1 (occurs once at top of file)		
IFLAGH	Flag to indicate hourly concentration file. A value of 12 is output to represent unit 12.	--
Record type 2 (occurs once at top of file)		
LINE1(20)	80-character title	--
LINE2(20)	80-character title	--
LINE3(20)	80-character title	--
Record type 3 (occurs once at top of file)		
METNAM(2)	8-character identifier of the meteorological data	--
MDATA	Month/day/year of data creation (6 digits)	mo/day/yr
MDATB	Hour/minute/second of data creation (6 digits)	hr/min/sec
ND	Number of 72-character lines of description	--
DESC(18,ND)	ND 72-character lines to describe the meteorological file	--
Record type 4 (occurs once at top of file)		
NPOL	4-character pollutant name	--
CONTWO	Multiplier to convert user length units to kilometers	km/uu
CELM	Multiplier to convert user height units to meters	m/uhu

(continued)

TABLE 11 (continued)

Variable	Description	Units
HAFL	Pollutant half-life. If zero, produced no pollutant loss	sec
NPTLIM	Number of point sources in this simulation	--
NRELIM	Number of receptors in this simulation	--
Record type 5 (occurs once at top of file)		
IOPT	Terrain adjustment option	--
IOPB	Buoyancy-induced dispersion option	--
IOPD	Stack-tip downwash option	--
IOPG	Gradual plume rise option	--
IOPM	Test against mixing at night	--
IOPQ	Hourly emissions input option	--
IOPR	Polar coordinate receptor option	--
Record type 6 (occurs once at top of file if IOPT = 1)		
CONTER(4)	Terrain adjustment factors	--
Record type 7 (NPTLIM records, one for each source, at top of file)		
PNAME	12-character (3A4) source identifier	--
QEAST	East coordinate of source	uu
QNORD	North coordinate of source	uu
QJ	Emission rate for pollutant NPOL	g/sec
PSH	Physical stack height	m
TS	Stack gas temperature	K
D	Stack diameter	m
VS	Stack gas exit velocity	g/sec
QELEV	Stack base ground-level elevation	uhu
IMPS	Significance rank of this source	--

(continued)

TABLE 11 (continued)

Variable	Description	Units
Record type 8 (occurs once at top of file; one for each receptor, that is, NRELIM records,)		
RNAME	8-character (2A4) receptor identifier	--
RREC	East coordinate of receptor	uu
SREC	North coordinate of receptor	uu
ZR	Receptor height above ground-level	m
ELR	Receptor ground-level elevation	uu
STAR	Flag (2A1) to indicate receptor status, * receptor elevation is below lowest stack base elevation ** receptor elevation is above lowest stack top elevation	--
(Note: Records 9, 10, and 11 are repeated in sequence for each hour.)		
Record type 9 (one for each hour)		
IYR	2-digit year	yr
IDY	Julian day	day
LH	Hour	hr
Record type 10 (one for each hour)		
HSAV	NPTLIM values of effective plume heights for each source followed by	m
DSAV	NPTLIM values of distance to final rise for each source	km
Record type 11 (one for each hour)		
PHCHI	Hourly concentrations at each receptor (NRELIM values)	g/m^3

TABLE 12. RECORD LAYOUT FOR THE PARTIAL CONCENTRATION FILE

Variable	Description	Units
Record type 1 (occurs once at top of file)		
IFLAGP	Flag to indicate partial concentration file. A value of 14 output to represent unit 14.	--
Record types 2 through 8 are identical to those given in Table 11		
Record type 9 (one for each hour)		
IYR	2-digit year	yr
IDY	Julian day	day
LH	Hour	hr
Record type 10 (one for each source for each hour,that is NPTLIM records per hour.)		
HSAV	Effective plume height for this source	m
DSAV	Distance to final rise for this source	km
PARTC	Concentrations from this source at each receptor (NRELIM values)	g/m^3

(Note: Records 9, 10, and 11 are repeated in sequence for each hour.)

Record types 1 through 8 are not repeated when the user requests additional simulation periods analyzed (i.e., record type 12 of Table 7 included in the input stream), since all other control information remains unchanged. Only hourly concentration results for each additional simulation period are written according to the specifications outlined in Tables 11 and 12. For instance, for all additional simulation periods only record types 9 through 11 are written to the hourly concentration file and only record types 9 and 10 are written to the partial concentration file. Record types 1 through 8 occur once at the top of the files.

ERROR MESSAGES AND REMEDIAL ACTION

TUPOS can generate 31 error messages. Each of these terminates program execution. Table 13 lists each error message, along with its description and suggested corrective action. The table is ordered on the condition code indicator, ICOND.

ICOND is used to indicate if an error is detected in the input data which would preclude model execution. A nonzero value is assigned to ICOND when an input error is detected. The first 3 digits of ICOND indicate the subprogram in which the error occurred; the last 2 digits indicate the relative position within the subprogram. For instance, if ICOND = 21003 then the error occurred in subroutine TU210 at assignment 3 of ICOND.

TABLE 13. ERROR MESSAGES AND REMEDIAL ACTION.

ICOND:	21002
MESSAGE:	*** CHECK OPTION LIST (I.E., RECORD TYPE 6). ***OPTION INPUT VARIABLES SHOULD BE EITHER 0 OR 1. ***EXECUTION TERMINATED, CONDITION CODE = 21002
DESCRIPTION:	User input value other than 0 or 1 for options.
ACTION:	Modify values on record type 6 to 0 or 1.
ICOND:	21003
MESSAGE:	*** CONTER VALUE IS OUTSIDE OF RANGE: ZERO TO ONE. *** EXECUTION TERMINATED, CONDITION CODE = 21003
DESCRIPTION:	One of the terrain adjustment factors is outside the acceptable range of between 0.0 to 1.0.

(continued)

TABLE 13 (continued)

ACTION: Change the offending value(s) of CONTER on record type 7. Values that were entered are printed prior to the error message.

ICOND: 21004

MESSAGE: *** USER TRIED TO INPUT MORE THAN xxxx POINT SOURCES.

*** EXECUTION TERMINATED, CONDITION CODE = 21004

DESCRIPTION: The user either entered more than the maximum number of point sources or forgot to place an 'ENDP' following the last point source.

ACTION: Reduce the number of point sources and/or place an 'ENDP' following the last point source.

ICOND: 21005

MESSAGE: *** INPUT DATA INDICATES THAT THERE ARE xxx POINT SOURCES FOR THIS SIMULATION.

*** EXECUTION TERMINATED, CONDITION CODE = 21005

DESCRIPTION: No sources were specified for this simulation.

ACTION: Revise the run stream so that it includes data for at least one point source.

ICOND: 21006

MESSAGE: *** TRYING TO GENERATE xxxxx RECEPTORS, BUT ARE ONLY ALLOWED xxxxx.

*** EXECUTION TERMINATED, CONDITION CODE = 21006

DESCRIPTION: The user is trying to generate more polar coordinate receptors than allowed.

(continued)

TABLE 13 (continued)

ACTION: Modify NAZ and NRAD on record type 9 so that their product does not exceed maximum number of receptors specified.

ICOND: 21007

MESSAGE: *** USER EITHER TRIED TO INPUT MORE THAN xxxxx RECEPTORS OR 'ENDR' WAS NOT PLACED AFTER THE LAST RECEPTOR RECORD.
*** EXECUTION TERMINATED, CONDITION CODE = 21007

DESCRIPTION: More receptors than maximum number specified (including polar coordinate receptors) were entered or an 'ENDR' was not placed after the last receptor record.

ACTION: Reduce the receptors input (including polar coordinate receptors) and/or place an 'ENDR' after the last receptor record.

ICOND: 210008

MESSAGE: *** NO RECEPTORS HAVE BEEN CHOSEN.
*** EXECUTION TERMINATED, CONDITION CODE = 21008

DESCRIPTION: No receptors have been generated or read in.

ACTION: Restructure the input stream so that receptors are generated and/or read.

ICOND: 22001

MESSAGE: *** YEAR INPUT (yyyy) IS NOT WITHIN RANGE OF 60-99.
*** EXECUTION TERMINATED, CONDITION CODE = 22001

DESCRIPTION: The year must be within the period 1960-1999.

ACTION: Modify starting year within input stream.

(continued)

TABLE 13 (continued)

ICOND: 22001

MESSAGE: *** JULIAN DAY INPUT (dddd) IS NOT WITHIN RANGE OF 1-366.
*** EXECUTION TERMINATED, CONDITION CODE = 22001

DESCRIPTION: A valid Julian day must be a positive number not greater than 366.

ACTION: Modify starting Julian day within input stream.

ICOND: 22001

MESSAGE: *** HOUR INPUT (hhhh) IS NOT WITHIN RANGE OF 1-24.
*** EXECUTION TERMINATED, CONDITION CODE = 22001

DESCRIPTION: The starting hour must be a 2-digit number between 1 and 24.

ACTION: Modify starting hour within input stream.

ICOND: 22001

MESSAGE: *** JULIAN DAY INPUT (dddd) CANNOT BE USED FOR YEAR yy; THIS IS NOT A LEAP YEAR.
*** EXECUTION TERMINATED, CONDITION CODE = 22001

DESCRIPTION: The starting year is not a leap year therefore the starting Julian day cannot equal 366.

ACTION: Modify Julian day within input stream.

ICOND: 22002

MESSAGE: *** COMMON SEQUENTIAL HOUR INPUT (hhhhhhh) IS NOT WITHIN THE REQUIRED RANGE FOR CONVERSION TO DATES BETWEEN YEARS 60 AND 99.
*** EXECUTION TERMINATED, CONDITION CODE = 22002

DESCRIPTION: The simulation period goes beyond December 31, 1999. This is outside the acceptable date range.

ACTION Reduce the simulation length (IHLIM) on record type 4.

(continued)

TABLE 13 (continued)

ICOND:	22003
MESSAGE:	*** ERROR READING MET FILE (UNIT 11). *** EXECUTION TERMINATED, CONDITION CODE = 22003
DESCRIPTION:	The meteorological file does not include the simulation start date.
ACTION:	Check the meteorological file and make sure it is complete for the simulation period.
ICOND:	22004
MESSAGE:	*** SYSTEM ERROR READING INPUT FOR NEXT SIMULATION PERIOD. *** EXECUTION TERMINATED, CONDITION CODE = 22004
DESCRIPTION:	An error occurred on reading the simulation start date and duration for the next run.
ACTION:	Make sure the record type 12 has sufficient values and they are of the proper data type.
ICOND:	30501
MESSAGE:	*** END OF FILE REACHED UPON ATTEMPTING TO READ HEADER RECORD OF MET FILE. *** EXECUTION TERMINATED, CONDITION CODE = 30501
DESCRIPTION:	The meteorology file is empty.
ACTION:	Check the contents of the file.
ICOND:	30502 to 30505
MESSAGE:	*** ID FROM MET FILE IS: xxxxxxxx yyyyyy zzzzzz *** EXPECTED ID IS: xxxxxxxx yyyyyy zzzzzz *** EXECUTION TERMINATED, CONDITION CODE = 30502 to 30505
DESCRIPTION:	The meteorology file identification does not match that provided on record type 5.

(continued)

TABLE 13 (continued)

ACTION:	Substitute the proper file in the job stream or change the identifier to match the data.
ICOND:	32001
MESSAGE:	*** xxxxxx HOURLY MET RECORDS WERE READ. *** THE MET FILE WAS EXHAUSTED WITHOUT FINDING DATA FOR HOUR REQUESTED. *** EXECUTION TERMINATED, CONDITION CODE = 32001
DESCRIPTION:	The meteorology file was exhausted without finding data for the hour requested.
ACTION:	Complete met file for the length of the simulation.
ICOND:	32002
MESSAGE:	*** YEAR INPUT (yyyy) IS NOT WITHIN RANGE OF 60-99. *** EXECUTION TERMINATED, CONDITION CODE = 32002
DESCRIPTION:	The year must be within the period 1960-1999.
ACTION:	Modify the year in the hourly meteorology record.
ICOND:	32002
MESSAGE:	*** JULIAN DAY INPUT (dddd) IS NOT WITHIN RANGE OF 1-366. *** EXECUTION TERMINATED, CONDITION CODE = 32002
DESCRIPTION:	A valid Julian day must be a positive number not greater than 366.
ACTION:	Modify the Julian day in the hourly meteorology record.
ICOND:	32002
MESSAGE:	*** HOUR INPUT (hhhh) IS NOT WITHIN RANGE OF 1-24. *** EXECUTION TERMINATED, CONDITION CODE = 32002

(continued)

TABLE 13 (continued)

DESCRIPTION: The starting hour must be a 2-digit number between 1 and 24.
ACTION: Modify the hour in the hourly meteorology record.

ICOND: 32002
MESSAGE: *** JULIAN DAY INPUT (dddd) CANNOT BE USED FOR YEAR yy; THIS IS NOT A LEAP YEAR.
*** EXECUTION TERMINATED, CONDITION CODE = 32002
DESCRIPTION: The year read in the hourly meteorology record is not a leap year therefore the Julian day read cannot equal 366.
ACTION: Modify the Julian day in the hourly meteorology record.

ICOND: 32501
MESSAGE: *** xxxxxx HOURLY EMISSION RECORDS WERE READ.
*** THE EMISSION FILE WAS EXHAUSTED WITHOUT FINDING THE HOUR REQUESTED.
*** EXECUTION TERMINATED, CONDITION CODE = 32501
DESCRIPTION: The emission file was exhausted without finding data for the hour requested.
ACTION: Complete the emissions file for the length of the simulation.

ICOND: 32502
MESSAGE: *** YEAR INPUT (yyyy) IS NOT WITHIN RANGE OF 60-99.
*** EXECUTION TERMINATED, CONDITION CODE = 32502
DESCRIPTION: The year must be within the period 1960-1999.
ACTION: Modify the year in the hourly emissions record.

(continued)

TABLE 13 (continued)

ICOND:	32502
MESSAGE:	*** JULIAN DAY INPUT (dddd) IS NOT WITHIN RANGE OF 1-366. *** EXECUTION TERMINATED, CONDITION CODE = 32502
DESCRIPTION:	A valid Julian day must be a positive number not greater than 366.
ACTION:	Modify the Julian day in the hourly emissions record.
ICOND:	32502
MESSAGE:	*** HOUR INPUT (hhhh) IS NOT WITHIN RANGE OF 1-24. *** EXECUTION TERMINATED, CONDITION CODE = 32502
DESCRIPTION:	The starting hour must be a 2-digit number between 1 and 24.
ACTION:	Modify the hour in the hourly emissions record.
ICOND:	32502
MESSAGE:	*** JULIAN DAY INPUT (dddd) CANNOT BE USED FOR YEAR yy; THIS IS NOT A LEAP YEAR. *** EXECUTION TERMINATED, CONDITION CODE = 32502
DESCRIPTION:	The year read in the hourly emissions record is not a leap year therefore the starting Julian day read cannot equal 366.
ACTION:	Modify the Julian day in hourly emissions record.
ICOND:	32503
MESSAGE:	*** YEAR-DAY-HOUR READ (yy-ddd-hh) EXCEEDS YEAR-DAY-HOUR REQUESTED (yy-ddd-hh). *** EXECUTION TERMINATED, CONDITION CODE = 32503
DESCRIPTION:	The year-day-hour read exceeds the year-day-hour requested. The emissions file in incomplete.

(continued)

TABLE 13 (continued)

ACTION:	The file must be complete for simulation period.
ICOND:	40501
MESSAGE:	*** SYSTEM ERROR ON READING HEADER RECORD OF MET FILE. *** EXECUTION TERMINATED, CONDITION CODE = 40501
DESCRIPTION:	An error occurred on reading the header record of the meteorology file.
ACTION:	Make sure the header record has sufficient values and they are of the proper data type.
ICOND:	40502
MESSAGE:	*** SYSTEM ERROR OCCURRED WHEN READING THE xxxxxxTH HOURLY MET RECORD. *** EXECUTION TERMINATED, CONDITION CODE = 40502
DESCRIPTION:	An error occurred on reading an hourly record from the meteorology file.
ACTION:	Check the corresponding record of the file.
ICOND:	43001
MESSAGE:	*** SYSTEM ERROR ON READING HOURLY EMISSION RECORD. *** EXECUTION TERMINATED, CONDITION CODE = 43001
DESCRIPTION:	An error occurred on reading an hourly record from the emissions file.
ACTION:	Check the corresponding record of the file.

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APPENDIX A

LISTING OF FORTRAN SOURCE CODE FOR TUPOS

The source code listing of TUPOS follows. The program consists of a main module, 29 subroutines, and 1 function.

```
C                   TUPOS-1.0 (VERSION 85091)
C                   AN AIR QUALITY DISPERSION MODEL IN
C                   SECTION 2. NON-GUIDELINE MODELS,
C                   IN UNAMAP (VERSION 6) JUL 86.
C                   SOURCE: UNAMAP FILE ON EPA'S UNIVAC 1110, RTP, NC.
C * * *  PROGRAM ABSTRACT -- TUPOS
C
C            THIS DISPERSION MODELING TECHNIQUE FOR ESTIMATING CONCEN-
C       TRATIONS FROM BUOYANT POINT SOURCES IS BASED UPON GAUSSIAN
C       ASSUMPTIONS AND CALCULATES THE GAUSSIAN PLUME SPREADING,
C       SIGMA-Y AND SIGMA-Z, UTILIZING HOURLY WIND FLUCTUATION STANDARD
C       DEVIATIONS AT PLUME HEIGHT DESCRIBED BY IRWIN (1983).
C       MULTI-LEVEL METEOROLOGICAL INFORMATION FOR LEVELS ABOVE GROUND
C       MUST BE FURNISHED IN A SEPARATE INPUT FILE.  METEOROLOGICAL
C       INPUT FILES COMPATIBLE WITH TUPOS INPUT REQUIREMENTS
C       CAN BE CREATED USING THE METEOROLOGICAL PROCESSOR MPDA-1
C       (PAUMIER, ET AL, 1986).  WIND SPEED
C       (INTERPOLATED VERTICALLY FROM THE INPUT DATA) IS USED BOTH FOR
C       ESTIMATION OF PLUME RISE AND FOR DILUTION.  WIND DIRECTION AT
C       THE PLUME HEIGHT IS USED AS THE TRANSPORT DIRECTION.  PLUME
C       RISE IS CALCULATED IN A LAYER-BY-LAYER MANNER USING THE INPUT
C       TEMPERATURE AND WIND SPEED PROFILES (TURNER, 1985).  TO ACCOUNT
C       FOR PLUME PENETRATION ABOVE THE MIXING HEIGHT, TUPOS USES THE
C       "TOP HAT" DISTRIBUTION RECOMMENDED BY BRIGGS (1975).
C       DISPERSION IS CALCULATED FROM,
C
C                     SIGY = X * SIGA * FY
C
C                     SIGZ = X * SIGE * FZ
C
C       WHERE SIGY AND SIGZ ARE THE STANDARD DEVIATION OF THE HORIZON-
C       TAL AND VERTICAL WIND ANGLES, RESPECTIVELY; AND FY AND FZ ARE
C       FUNCTIONS OF TRAVEL TIME AND STABILITY.  OPTIONS ARE AVAILABLE
C       FOR TERRAIN ADJUSTMENT, STACK DOWNWASH, GRADUAL PLUME RISE, AND
C       BUOYANCY-INDUCED DISPERSION.  COMPUTATIONS CAN BE MADE FOR ANY
C       NUMBER OF POINT SOURCES AT ANY NUMBER OF RECEPTOR LOCATIONS;
C       THE MAXIMUM NUMBER OF EACH IS SET AT THE TIME OF PROGRAM
C       COMPILATION.
C
C            OUTPUT PRINCIPALLY CONSISTS OF TAPE OR DISK CONCENTRATION
C       FILES WHICH ARE THEN ANALYZED AND SUMMARIZED BY A POSTPRO-
C       CESSOR, SUCH AS TUPOS-P (TURNER ET AL., 1985).  AN HOURLY
C       CONCENTRATION FILE IS AUTOMATICALLY CREATED BY TUPOS; THE USER
C       HAS THE OPTION OF CREATING A PARTIAL CONCENTRATION FILE.  FOR
C       CONVENIENCE, A BRIEF SUMMARY OF THE SIMULATION IS PRINTED;
C       HOWEVER, THE USER IS ENCOURAGED TO EXERCISE THE POSTPROCESSOR
C       TO OBTAIN A DETAILED LISTING OF THE RESULTS.
C
C * * *  REFERENCES
C
C       BRIGGS, G. A.  1975.  PLUME RISE PREDICTIONS.  IN:  LECTURES
C          ON AIR POLLUTION AND ENVIRONMENTAL IMPACT ANALYSIS, D. A.
C          HAUGEN (ED.).  AMER. METEOROL. SOC., BOSTON, MA.  PP 59-111.
C
C       IRWIN, J. S.  1983.  ESTIMATING PLUME DISPERSION -- A COMPARI-
C          SON OF SEVERAL SIGMA SCHEMES.  JOURNAL OF CLIMATE AND
C          APPLIED METEOROLOGY 22: 92-114.
C
C       PAUMIER, J., D. STINSON, T. KELLY, C. BOLLINGER, AND J. S.
C          IRWIN, 1986.  MPDA-1: A METEOROLOGICAL PROCESSOR FOR
C          DIFFUSION ANALYSIS - USER'S GUIDE.  EPA-600/ 8-86/011.
C          U. S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH
C          TRIANGLE PARK, NC. 192PP.
C
C       PIERCE, THOMAS E., AND TURNER, D. BRUCE, 1980: USER'S GUIDE
C          FOR MPTER - A MULTIPLE POINT GAUSSIAN DISPERSION ALGORITHM
C          WITH OPTIONAL TERRAIN ADJUSTMENT.  EPA-600/8-80-016.  U. S.
C          ENVIRONMENTAL PROTECTION AGENCY. RESEARCH TRIANGLE PARK, NC
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C            239 P.                                                     TUP00710
C                                                                       TUP00720
C        TURNER, D. B.  1985.  PROPOSED PRAGMATIC METHODS FOR ESTIMATINGTUP00730
C           PLUME RISE AND PLUME PENETRATION THROUGH ATMOSPHERIC LAYERS.TUP00740
C           "PRELIMINARY COMMUNICATION" IN ATMOS. ENVIRON. 19, 7, 1215- TUP00750
C           1218.                                                       TUP00760
C                                                                       TUP00770
C        TURNER, D. B., T. CHICO, AND J. A. CATALANO.  1986.  TUPOS --  TUP00780
C           A MULTIPLE SOURCE GAUSSIAN DISPERSION ALGORITHM USING       TUP00790
C           ON-SITE TURBULENCE DATA.  EPA/600/ 8-86/010.  U. S. ENVIRON-TUP00800
C           MENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NC.       TUP00810
C           171PP.                                                      TUP00820
C                                                                       TUP00830
C        TURNER, D. B., T. CHICO, AND J. A. CATALANO.  1986.  TUPOS-P --TUP00840
C           A PROGRAM FOR ANALYZING HOURLY AND PARTIAL CONCENTRATION    TUP00850
C           FILES PRODUCED BY TUPOS.  EPA/600/ 8-86/012.  U. S. ENVIRON-TUP00860
C           MENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NC.       TUP00870
C           106 PP.                                                     TUP00880
C                                                                       TUP00890
C * * *  AUTHORS OF MODEL CODE FOR TUPOS                                TUP00900
C                                                                       TUP00910
C             D. BRUCE TURNER* AND TOM CHICO#                           TUP00920
C             *ON ASSIGNMENT TO EPA FROM NOAA, DEPT OF COMMERCE.        TUP00930
C             #AEROCOMP, INC.                                           TUP00940
C                                                                       TUP00950
C                                                                       TUP00960
C * * *  ACKNOWLEDGMENTS                                                TUP00970
C                                                                       TUP00980
C             THE AUTHORS OF THE MODEL CODE ARE GRATEFUL TO ALFREIDA D. TUP00990
C        RANKINS FOR HER COMPUTER ASSISTANCE AND EXPERTISE, TO THOMAS   TUP01000
C        E. PIERCE FOR HIS WORK ON THE MPTER WHICH FORMED A CONVENIENT  TUP01010
C        FOUNDATION FOR THIS MODEL, AND TO JOHN S. IRWIN FOR HELPFUL    TUP01020
C        DISCUSSIONS AND DETAILED EXAMINATION OF MODEL CODE.            TUP01030
C                                                                       TUP01040
C             A MODEL IS ONLY AS GOOD AS ITS WEAKEST INPUT DATA AND IT  TUP01050
C        SHOULD BE NOTED THAT THE ENVIRONMENTAL OPERATIONS BRANCH HAS   TUP01060
C        BEGUN WORK BY CONTRACT AND INTERAGENCY AGREEMENT POINTED       TUP01070
C        TOWARD EVALUATING VARIOUS METEOROLOGICAL INSTRUMENT SYSTEMS AS TUP01080
C        TO THEIR ABILITY TO MEASURE ATMOSPHERIC VELOCITY AND           TUP01090
C        TURBULENCE.  PROJECT OFFICER FOR THIS EFFORT IS DR. P. L.      TUP01100
C        FINKELSTEIN.  TWO REPORTS RESULTING FROM THIS EFFORT ARE:      TUP01110
C                                                                       TUP01120
C         KAIMAL, J.C., J. E. GAYNOR, P. L. FINKELSTEIN, M. E.          TUP01130
C            GRAVES AND T. J. LOCKHART, 1985: AN EVALUATION OF          TUP01140
C            WIND MEASUREMENTS BY FOUR DOPPLER SODARS. EPA-600/         TUP01150
C            3-84-111. U. S. ENVIRONMENTAL PROTECTION AGENCY.           TUP01160
C            RESEARCH TRIANGLE PARK, NC. 124 PP. (AVAILABLE             TUP01170
C            ONLY FROM NTIS, ACCESSION NUMBER PB85-115 301.)            TUP01180
C                                                                       TUP01190
C         KAIMAL, J.C., J. E. GAYNOR, P. L. FINKELSTEIN, M. E.          TUP01200
C            GRAVES AND T. J. LOCKHART, 1985: A FIELD COMPARISON        TUP01210
C            OF IN SITU METEOROLOGICAL SENSORS. EPA-600/                TUP01220
C            3-85-057. U. S. ENVIRONMENTAL PROTECTION                   TUP01230
C            AGENCY. RESEARCH TRIANGLE PARK, NC. 108 PP.                TUP01240
C            (AVAILABLE ONLY FROM NTIS, ACCESSION NUMBER                TUP01250
C            PB85-196 988.)                                             TUP01260
C                                                                       TUP01270
C * * *  PROGRAM SUPPORTED BY:                                          TUP01280
C                                                                       TUP01290
C        ENVIRONMENTAL OPERATIONS BRANCH                                TUP01300
C        MAIL DROP 80, EPA                                              TUP01310
C        RESEARCH TRIANGLE PARK, NC  27711                              TUP01320
C                                                                       TUP01330
C        PHONE: (919) 541-4564,  FTS 629-4564.                          TUP01340
C                                                                       TUP01350
C                                                                       TUP01360
C * * *  TWO SYSTEMS OF LENGTH AND COORDINATES ARE USED IN THIS PROGRAM:TUP01370
C                                                                       TUP01380
C             THE FIRST SYSTEM, USER UNITS, IS SELECTED BY THE USER AND TUP01390
C        NORMALLY USES THE COORDINATE SYSTEM OF THE EMISSION INVENTORY. TUP01400
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C        ALL LOCATIONS INPUT BY THE USER (SUCH AS SOURCES AND RECEPTORS)TUP01410
C        ARE IN THIS SYSTEM. ALSO AS A CONVENIENCE TO THE USER, ALL     TUP01420
C        LOCATIONS ON OUTPUT ARE ALSO IN THIS SYSTEM.                   TUP01430
C                                                                       TUP01440
C             THE SECOND SYSTEM, X, Y, IS AN UPWIND, CROSSWIND          TUP01450
C        COORDINATE SYSTEM RELATIVE TO EACH RECEPTOR.  THE X-AXIS IS    TUP01460
C        DIRECTED UPWIND (SAME AS WIND DIRECTION FOR THE HOUR).  IN     TUP01470
C        ORDER TO DETERMINE DISPERSION PARAMETER VALUES AND EVALUATE    TUP01480
C        EQUATIONS FOR CONCENTRATION ESTIMATES, DISTANCES IN THIS       TUP01490
C        SYSTEM MUST BE IN KILOMETERS. THIS SYSTEM IS INTERNAL AND IS   TUP01500
C        NOT APPARENT TO THE USER.                                      TUP01510
C                                                                       TUP01520
C * * *  INPUT/OUTPUT INFORMATION                                       TUP01530
C                                                                       TUP01540
C        FORTRAN     DATA SET                       I/O UNIT            TUP01550
C         UNIT                                                          TUP01560
C          5         CONTROL INPUT                  READER OR DISK      TUP01570
C          6         OUTPUT                         PRINTER OR DISK     TUP01580
C          9         METEOROLOGY (IN)               DISK OR TAPE        TUP01590
C         10         HOURLY EMISSIONS (IN)          DISK OR TAPE        TUP01600
C         12         HOURLY CONCENTRATIONS (OUT)    DISK OR TAPE        TUP01610
C         14         PARTIAL CONCENTRATIONS (OUT)   DISK OR TAPE        TUP01620
C                                                                       TUP01630
C * * *  STRUCTURE AND MODULE SUMMARY                                   TUP01640
C                                                                       TUP01650
C TU100 - MODEL MULTILEVEL BUOYANT PLUME                                TUP01660
C         TU210 - PROCESS CONTROL INPUTS                                TUP01670
C                 TU305 - GET MET FILE HEADER                           TUP01680
C                         TU405 - READ MET FILE                         TUP01690
C                 TU310 - PROCESS SOURCE INPUT                          TUP01700
C                         TU410 - CHARACTERIZE SOURCES                  TUP01710
C                         TU415 - RANK SIGNIFICANT SOURCES              TUP01720
C                 TU315 - PROCESS RECEPTOR INPUT                        TUP01730
C                         TU420 - GENERATE POLAR RECEPTORS              TUP01740
C                         TU425 - PRODUCE RECEPTOR TABLE                TUP01750
C         TU220 - EXECUTE DISPERSION SIMULATION                         TUP01760
C                         CHRON - DATE/TIME TO INTEGER                  TUP01770
C                         ICHRON - INTEGER TO DATE/TIME                 TUP01780
C                 TU320 - GET HOURLY MET DATA                           TUP01790
C                         TU405 - READ MET FILE                         TUP01800
C                         CHRON - DATE/TIME TO INTEGER                  TUP01810
C                 TU325 - GET HOURLY EMISSIONS                          TUP01820
C                         TU430 - READ EMISSIONS FILE                   TUP01830
C                         CHRON - DATE/TIME TO INTEGER                  TUP01840
C                 TU330 - CALCULATE CONCENTRATIONS                      TUP01850
C                         TU435 - CALCULATE LAYER-BY-LAYER PLUME RISE   TUP01860
C                                 TU510 - CALCULATE POTENTIAL           TUP01870
C                                         TEMPERATURE GRADIENT          TUP01880
C                                 TU515 - CALCULATE STACK TIP           TUP01890
C                                         DOWNWASH                      TUP01900
C                                 TU520 - UNSTABLE NEUTRAL BUOYANCY RISETUP01910
C                                 TU530 - UNSTABLE NEUTRAL RESIDUAL     TUP01920
C                                         BUOYANCY                      TUP01930
C                                 TU540 - STABLE BUOYANCY RISE          TUP01940
C                                 TU550 - STABLE RESIDUAL BUOYANCY      TUP01950
C                         TU440 - CALCULATE PLUME PENETRATION           TUP01960
C                         TU445 - CALCULATE EMISSION METEOROLOGY        TUP01970
C                         TU450 - CALCULATE DISPERSION PARAMETERS       TUP01980
C                         TU455 - CALCULATE RELATIVE CONCENTRATION      TUP01990
C                         ZF    - FIND HEIGHT OF MAXIMUM.               TUP02000
C                 TU335 - UPDATE MAXIMUM CONCENTRATION                  TUP02010
C                 TU340 - OUTPUT HOURLY RESULTS                         TUP02020
C                                                                       TUP02030
      PARAMETER (NLMAX=20,NPTMAX=25,NREMAX=180,NDMAX=40)                TUP02040
C                                                                       TUP02050
C        USE OF PARAMETER STATEMENT SETS: MAXIMUMS FOR                  TUP02060
C         NUMBER OF VERTICAL LEVELS FOR METEOROLOGY (NLMAX),            TUP02070
C         NUMBER OF POINT SOURCES (NPTMAX),                             TUP02080
C         NUMBER OF RECEPTORS (NREMAX), AND                             TUP02090
C         NUMBER OF LINES OF DESCRIPTION OF MET INFORMATION (NDMAX).    TUP02100
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C                                                                       TUP02110
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,    TUP02120
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,     TUP02130
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT    TUP02140
      COMMON /METCOM/DTHDZ(NLMAX),SAL(NLMAX),SEL(NLMAX),TL(NLMAX),      TUP02150
     1               UL(NLMAX),WDL(NLMAX),ZL(NLMAX),KLASS,LMX,MDATA,    TUP02160
     2               MDATB,METNAM(2),MYR,MJD,MHR,ND,NLLIM,DESC(18,NDMAX)TUP02170
      COMMON /SORCOM/D(NPTMAX),PNAME(3,NPTMAX),PSH(NPTMAX),QJ(NPTMAX),  TUP02180
     1               QELEV(NPTMAX),QEAST(NPTMAX),QNORD(NPTMAX),         TUP02190
     2               TS(NPTMAX),VS(NPTMAX),IQYR,IQJD,IQHR,NPTLIM,       TUP02200
     3               IMPS(NPTMAX)                                       TUP02210
      COMMON /RECCOM/ELR(NREMAX),PARTC(NREMAX,NPTMAX),PHCHI(NREMAX),    TUP02220
     1               RNAME(2,NREMAX),RREC(NREMAX),SREC(NREMAX),         TUP02230
     2               STAR(2,NREMAX),ZR(NREMAX),NRELIM                   TUP02240
      COMMON /INOUT/ IN,IO                                              TUP02250
      DATA BLANK/' '/                                                   TUP02260
C                                                                       TUP02270
C         WRITE HEADER.                                                 TUP02280
C                                                                       TUP02290
      WRITE (6,1234)                                                    TUP02300
 1234 FORMAT ('1',21X,'TUPOS-1.0 (VERSION 85091)'/                      TUP02310
     1 22X,'AN AIR QUALITY DISPERSION MODEL IN'/                        TUP02320
     2 22X,'SECTION 2. NON-GUIDELINE MODELS,'/                          TUP02330
     3 22X,'IN UNAMAP (VERSION 6) JUL 86.'/                             TUP02340
     4 22X,'SOURCE: UNAMAP FILE ON EPA''S UNIVAC 1110, RTP, NC.')       TUP02350
C                                                                       TUP02360
C          INITIALIZE.                                                  TUP02370
C                                                                       TUP02380
      IN = 5                                                            TUP02390
      IO = 6                                                            TUP02400
      ICOND = 0                                                         TUP02410
      DO 20 I = 1,2                                                     TUP02420
         DO 10 J = 1,NREMAX                                             TUP02430
            STAR(I,J) = BLANK                                           TUP02440
   10    CONTINUE                                                       TUP02450
   20 CONTINUE                                                          TUP02460
C                                                                       TUP02470
C           PROCESS CONTROL INPUTS.                                     TUP02480
C                                                                       TUP02490
      CALL TU210(ICOND)                                                 TUP02500
      IF (ICOND .EQ. 0) GO TO 100                                       TUP02510
      WRITE(IO,1000)ICOND                                               TUP02520
      GO TO 999                                                         TUP02530
C                                                                       TUP02540
C          EXECUTE DISPERSION SIMULATION.                               TUP02550
C                                                                       TUP02560
  100 CALL TU220(ICOND)                                                 TUP02570
      IF (ICOND .EQ. 0) GO TO 200                                       TUP02580
      WRITE(IO,1000)ICOND                                               TUP02590
      GO TO 999                                                         TUP02600
C                                                                       TUP02610
C         SUCCESSFUL EXECUTION.                                         TUP02620
C                                                                       TUP02630
  200 WRITE(IO,1010)                                                    TUP02640
C                                                                       TUP02650
  999 STOP                                                              TUP02660
C                                                                       TUP02670
C          FORMAT STATEMENTS.                                           TUP02680
C                                                                       TUP02690
 1000 FORMAT('0*** EXECUTION TERMINATED, CONDITION CODE = ',I5)         TUP02700
 1010 FORMAT('0*** NORMAL TERMINATION ***')                             TUP02710
      END                                                               TUP02720
C
      SUBROUTINE TU210(ICOND)                                           TUP02730
C         210-PROCESS-CONTROL-INPUTS                                    TUP02740
C                                                                       TUP02750
C         PARAMETER LIST:                                               TUP02760
C           OUTPUT:  ICOND - CONDITION INDICATOR (0 = NO ERROR)         TUP02770
C                                                                       TUP02780
C         CALLING ROUTINES:                                             TUP02790
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C          MAIN                                                         TUP02800
C                                                                       TUP02810
C        SUBPROGRAMS CALLED:                                            TUP02820
C          TU305, TU310, TU315                                          TUP02830
C                                                                       TUP02840
C        DESCRIPTION:                                                   TUP02850
C          THIS MODULE PERFORMS ALL INPUT OPERATIONS TO UNIT 5, THE     TUP02860
C          CONTROL INPUT FILE AND CALLS A NUMBER OF MODULES TO PROCESS  TUP02870
C          THE INPUT.  IF AN ERROR IS DETECTED IN THE DATA WHICH        TUP02880
C          PRECLUDES MODEL EXECUTION, A NONZERO VALUE IS ASSIGNED TO    TUP02890
C          ICOND.                                                       TUP02900
C                                                                       TUP02910
C* * * * * * * * * * * CONTROL INPUT DATA (UNIT 5) * * * * * * * * * * *TUP02920
C                                                                       TUP02930
C                                                                       TUP02940
C***   RECORD TYPES 1-3:  ALPHANUMERIC DATA FOR TITLES. FORMAT(20A4)    TUP02950
C                                                                       TUP02960
C        LINE1 - 80 ALPHANUMERIC CHARACTERS.                            TUP02970
C        LINE2 - 80 ALPHANUMERIC CHARACTERS.                            TUP02980
C        LINE3 - 80 ALPHANUMERIC CHARACTERS.                            TUP02990
C                                                                       TUP03000
C***   RECORD TYPE 4:  CONTROL.            FORMAT (FREE)                TUP03010
C                                                                       TUP03020
C        IYRS      -  2-DIGIT YEAR FOR THIS SIMULATION.                 TUP03030
C        IDYS      -  STARTING JULIAN DAY FOR THIS SIMULATION.          TUP03040
C        IHRS      -  STARTING HOUR FOR THIS SIMULATION.                TUP03050
C        IHLIM     -  THE TOTAL NUMBER OF HOURS TO BE SIMULATED.        TUP03060
C        CONTWO    -  MULTIPLIER TO CONVERT USER UNITS TO KILOMETERS.   TUP03070
C                        EXAMPLE MULTIPLIERS:                           TUP03080
C                          FEET TO KM    3.048E-04                      TUP03090
C                          MILES TO KM   1.609344                       TUP03100
C                          METERS TO KM  1.0E-03                        TUP03110
C        CELM      -  MULTIPLIER TO CONVERT USER HEIGHT UNITS TO METERS.TUP03120
C                        EXAMPLE MULTIPLIER:                            TUP03130
C                          FEET TO METERS  0.3048                       TUP03140
C        HAFL      -  POLLUTANT HALF-LIFE (SECONDS); AN ENTRY OF ZERO   TUP03150
C                       WILL CAUSE NO POLLUTANT LOSS.                   TUP03160
C                                                                       TUP03170
C***   RECORD TYPE 5:  MET DATA IDENTIFIERS.   FORMAT (3A4,2I6)         TUP03180
C                                                                       TUP03190
C       METID, MDATAC, MDATBC WILL BE USED TO COMPARE                   TUP03200
C        WITH INFO IN FIRST RECORD OF MET FILE TO INSURE                TUP03210
C        PROPER DATA USED.                                              TUP03220
C                                                                       TUP03230
C       NPOL       -  4 CHARACTER POLLUTANT NAME.                       TUP03240
C       METID      -  8 CHARACTER IDENTIFIER.                           TUP03250
C       MDATAC     -  MO DAY YR OF DATA CREATION (6 DIGITS).            TUP03260
C       MDATBC     -  HR MIN SEC OF DATA CREATION (6 DIGITS).           TUP03270
C                                                                       TUP03280
C***   RECORD TYPE 6:  TECHNICAL & EXTERNAL FILE OPTIONS. FORMAT (FREE) TUP03290
C                                                                       TUP03300
C       NPRNT      -  NO. HRS PRINTED OUTPUT                            TUP03310
C                                                                       TUP03320
C       1 = EMPLOY OPTION;  0 = DON'T USE OPTION.                       TUP03330
C                                                                       TUP03340
C      TECHNICAL OPTIONS:                                               TUP03350
C       IOPT       -  USE TERRAIN ADJUSTMENTS.                          TUP03360
C       IOPB       -  USE BUOYANCY INDUCED DISPERSION.                  TUP03370
C       IOPD       -  NO STACK TIP DOWNWASH.                            TUP03380
C       IOPG       -  NO GRADUAL PLUME RISE.                            TUP03390
C       IOPM       -  TEST FOR PLUME WITHIN TURBULENT BOUNDARY          TUP03400
C                       LAYER (NIGHTTIME).                              TUP03410
C       IDFLT      -  OPTION FOR DEFAULT VALUES.                        TUP03420
C                        EMPLOYING DEFAULT OPTION USES MODEL FEATURES   TUP03430
C                          ACCORDING TO AUTHOR'S PREFERENCE.            TUP03440
C                                                                       TUP03450
C      INPUT OPTIONS:                                                   TUP03460
C       IOPQ       -  READ HOURLY EMISSIONS.(UNIT 10)                   TUP03470
C       IOPR       -  INPUT RADIAL DISTANCES AND GENERATE POLAR         TUP03480
C                      COORDINATE RECEPTORS.                            TUP03490
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C                                                                       TUP03500
C       OUTPUT OPTIONS:                                                 TUP03510
C         IOPWPC   -  WRITE PARTIAL CONCENTRATIONS TO DISK OR TAPE      TUP03520
C                       UNIT 14.                                        TUP03530
C                                                                       TUP03540
C***    RECORD TYPE 7:  TERRAIN ADJUSTMENT FACTORS.  FORMAT (FREE)      TUP03550
C                       READ ONLY IF IOPT IS 1.                         TUP03560
C         CONTER(I), I = 1,4 (MUST BE BETWEEN 0. AND 1.)                TUP03570
C                                                                       TUP03580
C***    RECORD TYPE 8:  POINT SOURCE CARD.  FORMAT(3A4,7F8.2,F4.0)      TUP03590
C                                                                       TUP03600
C       (UP TO NPTMAX  POINT SOURCE CARDS ARE ALLOWED.)                 TUP03610
C        PNAME(I,NPT)  1-12  3A4 12 CHARACTER SOURCE IDENTIFICATION.    TUP03620
C        QEAST(NPT)   13-20 F8.2 EAST COORD. OF PT. SOURCE (USER UNITS) TUP03630
C        QNORD(NPT)   21-28 F8.2 NORTH COORD. OF PT. SOURCE (USER UNITS)TUP03640
C        QJ(NPT)      29-36 F8.2 EMISSION RATE (G/SEC) FOR POLLUTANT NPOTUP03650
C        PSH(NPT)     37-44 F8.2 PHYSICAL STACK HEIGHT (METERS)         TUP03660
C        TS(NPT)      45-52 F8.2 STACK GAS TEMPERATURE (KELVIN)         TUP03670
C        D(NPT)       53-60 F8.2 STACK TOP INSIDE DIAMETER (METERS)     TUP03680
C        VS(NPT)      61-68 F8.2 STACK GAS EXIT VELOCITY (M/SEC)        TUP03690
C        QELEV(NPT)   69-72 F4.0 STACK BASE GROUND-LEVEL ELEVATION      TUP03700
C                                  (USER HEIGHT UNITS)                  TUP03710
C                                                                       TUP03720
C   !!! IMPORTANT !!!                                                   TUP03730
C        RECORD WITH ENDP IN COLS 1-4 IS USED TO SIGNIFY END OF POINT   TUP03740
C         SOURCE INPUT.                                                 TUP03750
C                                                                       TUP03760
C***    RECORD TYPE 9:  POLAR COORDINATE RECEPTORS.  FORMAT (FREE)      TUP03770
C                                                                       TUP03780
C       (USED IF IOPR = 1)                                              TUP03790
C        CEST       EAST COORDINATE ABOUT WHICH POLAR COORD GRID IS     TUP03800
C                    CENTERED (USER UNITS).                             TUP03810
C        CNOR       NORTH COORDINATE ABOUT WHICH POLAR COORD GRID IS    TUP03820
C                    CENTERED (USER UNITS).                             TUP03830
C        NAZ        NUMBER OF AZIMUTHS.                                 TUP03840
C        AZBEG      BEGINNING AZIMUTH (DEGREES, CLOCKWISE FROM NORTH).  TUP03850
C        AZINT      AZIMUTH INTERVAL (DEGREES).                         TUP03860
C        NRAD       NUMBER OF RADIALS.                                  TUP03870
C        RADIL      RADIAL DISTANCES (USER UNITS; NRAD OF THESE).       TUP03880
C                                                                       TUP03890
C         NOTE THAT IF NO TERRAIN AND NO RECEPTOR COORD TO BE           TUP03900
C          READ IN, MUST HAVE AN 'ENDR' RECORD HERE!!                   TUP03910
C                                                                       TUP03920
C***    RECORD TYPE 10:  POLAR COORDINATE RECEPTOR ELEV. FORMAT (FREE)  TUP03930
C         INPUT ONLY IF BOTH IOPT = 1 AND IOPR = 1.                     TUP03940
C                                                                       TUP03950
C       ELR - POLAR COORDINATE RECEPTOR ELEVATION (USER HT UNITS)       TUP03960
C            READ IN RECEPTOR ELEVATIONS (USER HEIGHT UNITS) ORDERING   TUP03970
C       SO THAT ALL AZIMUTHS FOR THE FIRST RADIAL DISTANCE ARE ENTERED  TUP03980
C       FIRST, THEN ALL AZIMUTHS FOR EACH SUCCEEDING RADIAL.            TUP03990
C                                                                       TUP04000
C        NOTE THAT IF NO RECEPTOR COORDINATES TO BE READ IN,            TUP04010
C         MUST HAVE AN 'ENDR' RECORD HERE!!                             TUP04020
C                                                                       TUP04030
C***    RECORD TYPE 11:  RECEPTORS.  FORMAT(2A4,2F10.3,2F10.0)          TUP04040
C                                                                       TUP04050
C       (UP TO NREMAX RECEPTORS MAY BE GENERATED INCLUDING POLAR        TUP04060
C        COORDINATE ONES IF IOPR = 1.)                                  TUP04070
C       RNAME(I),I=1,2 ( 1- 8)  2A4  8 DIGIT ALPHANUMERIC STATION       TUP04080
C        IDENTIFICATION.                                                TUP04090
C       RREC (9-18)  F10.3 EAST COORDINATE OF RECEPTOR (USER UNITS)     TUP04100
C       SREC (19-28) F10.3 NORTH COORDINATE OF RECEPTOR (USER UNITS)    TUP04110
C       ZR   (29-38) F10.0 RECEPTOR HEIGHT ABV LOCAL GROUND-LEVEL (M)   TUP04120
C       ELR  (39-48) F10.0 RECEPTOR GRD-LVL ELEVATION (USER HT UNITS)   TUP04130
C   !!! IMPORTANT !!!                                                   TUP04140
C        RECORD WITH 'ENDR' IN COLS 1-4 IS USED TO SIGNIFY THE END OF   TUP04150
C         THE RECEPTOR RECORDS.                                         TUP04160
C                                                                       TUP04170
C***    RECORD TYPE 12:  ADDITIONAL SIMULATION PERIOD.  FORMAT (FREE)   TUP04180
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C
C        IYRS      -  2-DIGIT YEAR FOR ADDITIONAL SIMULATION PERIOD.
C        IDAYS     -  STARTING JULIAN DAY FOR THIS SIMULATION.
C        IHRS      -  STARTING HOUR FOR THIS SIMULATION.
C        IHLIM     -  THE TOTAL NUMBER OF ADDITIONAL HRS TO BE SIMULATED.
C
      PARAMETER (NPTMAX=25,NREMAX=180,NRL=15)
      DIMENSION METID(2),RADIL(NRL)
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT
      COMMON /SORCOM/D(NPTMAX),PNAME(3,NPTMAX),PSH(NPTMAX),QJ(NPTMAX),
     1               QELEV(NPTMAX),QEAST(NPTMAX),QNORD(NPTMAX),
     2               TS(NPTMAX),VS(NPTMAX),IQYR,IQJD,IQHR,NPTLIM,
     3               IMPS(NPTMAX)
      COMMON /RECCOM/ELR(NREMAX),PARTC(NREMAX,NPTMAX),PHCHI(NREMAX),
     1               RNAME(2,NREMAX),RREC(NREMAX),SREC(NREMAX),
     2               STAR(2,NREMAX),ZR(NREMAX),NRELIM
      COMMON /INOUT/ IN,IO
      DATA ENDP/'ENDP'/, ENDR/'ENDR'/
C
C         READ RECORD TYPES 1-3.
C
      READ(IN,1000) LINE1,LINE2,LINE3
      WRITE(IO,3000) LINE1,LINE2,LINE3
C
C         READ RECORD TYPES 4 AND 5.
C
      READ(IN,*) IYRS,IDYS,IHRS,IHLIM,CONTWO,CELM,HAFL
      READ(IN,1010) NPOL,METID,MDATAC,MDATBC
C
C         READ HEADER RECORD OF MET FILE.
C
      CALL TU305(METID,MDATAC,MDATBC,ICOND)
      IF (ICOND .NE. 0) GO TO 999
C
C         READ RECORD TYPE 6.
C
      READ(IN,*) NPRNT,IOPT,IOPB,IOPD,IOPG,IOPM,IDFLT,IOPQ,IOPR,IOPWPC
      IF ((IOPT .NE. 0) .AND. (IOPT .NE. 1)) ICOND = 21002
      IF ((IOPB .NE. 0) .AND. (IOPB .NE. 1)) ICOND = 21002
      IF ((IOPD .NE. 0) .AND. (IOPD .NE. 1)) ICOND = 21002
      IF ((IOPG .NE. 0) .AND. (IOPG .NE. 1)) ICOND = 21002
      IF ((IOPM .NE. 0) .AND. (IOPM .NE. 1)) ICOND = 21002
      IF ((IOPQ .NE. 0) .AND. (IOPQ .NE. 1)) ICOND = 21002
      IF ((IOPR .NE. 0) .AND. (IOPR .NE. 1)) ICOND = 21002
      IF ((IOPWPC .NE. 0) .AND. (IOPWPC .NE. 1)) ICOND = 21002
      IF ((IDFLT.NE.0).AND.(IDFLT.NE.1)) ICOND = 21002
      IF (ICOND .EQ. 0) GO TO 50
      WRITE(IO,2005)
      GO TO 999
C
C         WRITE GENERAL INPUT INFORMATION.
C
   50 WRITE(IO,3010) NPOL,IYRS,IDYS,IHRS,IHLIM,CONTWO
      IF (HAFL .GT. 0.0) GO TO 60
      TLOS = 0.
      WRITE (IO,3020)
      GO TO 80
   60 WRITE(IO,3030) HAFL
      TLOS = 693./HAFL
   80 IF (IOPT .EQ. 0) GO TO 100
      IF(CELM .EQ. 0.) CELM = 1.
      WRITE(IO,3040) CELM
  100 WRITE(IO,3050) NPRNT
      WRITE(IO,3060) IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR
      WRITE(IO,3070) IOPWPC
C
C         READ RECORD TYPE 7.
C
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      IF (IOPT .EQ. 0) GO TO 140
      READ(IN,*) CONTER
      WRITE(IO,3080) CONTER
      DO 120 I=1,4
         IF ((CONTER(I) .LT. 0.) .OR. (CONTER(I) .GT. 1.)) GO TO 130
  120 CONTINUE
      GO TO 140
  130 WRITE (IO,2010)
      ICOND = 21003
      GO TO 999
C
C         GET SOURCE INFORMATION.
C
  140 NPT=0
C         IF DEFAULT, SET VALUES.
C          NOTE THAT DEFAULT (TO EXECUTE TUPOS ACCORDING TO
C          AUTHOR'S PREFERENCE) USES BUOYANCY-INDUCED DISPERSION,
C          STACK-TIP DOWNWASH, DOES NOT USE GRADUAL RISE (EXCEPT
C          FOR THE MAGNITUDE OF THE BID); AND IF THE TERRAIN
C          OPTION IS BEING USED, USES HALF-HEIGHT RISE OVER
C          TERRAIN FEATURES FOR UNSTABLE AND DAYTIME NEUTRAL,
C          AND LEVEL PLUMES FOR NIGHTTIME NEUTRAL AND STABLE.
      IF (IDFLT.EQ.0) GO TO 150
      IOPB = 1
      IOPD = 0
      IOPG = 1
      IF (IOPT.EQ.0) GO TO 150
      CONTER(1) = 0.5
      CONTER(2) = 0.5
      CONTER(3) = 0.0
      CONTER(4) = 0.0
C         BEGIN LOOP TO READ THE POINT SOURCE INFORMATION.
  150 NPT = NPT + 1
      IF (NPT .LE. NPTMAX) GO TO 160
      READ(IN,1020) DUM
      IF (DUM .EQ. ENDP) GO TO 230
      WRITE(IO,2020) NPTMAX
      ICOND = 21004
      GO TO 999
C         READ RECORD TYPE 8 -- SOURCE INFORMATION.
  160 READ(IN,1030) (PNAME(I,NPT), I = 1,3),QEAST(NPT),QNORD(NPT),
     1              QJ(NPT),PSH(NPT),TS(NPT),D(NPT),
     2              VS(NPT),QELEV(NPT)
C         CARD WITH 'ENDP' IN COL 1-4 IS USED TO SIGNIFY END OF POINT
C         SOURCES.
      IF (PNAME(1,NPT) .EQ. ENDP) GO TO 230
C         GO BACK AND READ NEXT SOURCE.
      GO TO 150
  230 NPT = NPT - 1
      NPTLIM = NPT
C         CHECK FOR NPT < OR = 0
      IF (NPT .GT. 0) GO TO 240
      WRITE(IO,2030) NPT
      ICOND = 21005
      GO TO 999
C
C         PROCESS SOURCE INPUT.
C
  240 ELHN = 99999.
      ELOW = 99999.
      CALL TU310(ELOW,ELHN)
C
C         GET RECEPTOR INFORMATION.
C
      NRELIM = 0
      WRITE(IO,3090) LINE1,LINE2,LINE3
      WRITE(IO,3100)
      IF (IOPR .EQ. 0) GO TO 520
C
C         READ RECORD TYPE 9.
```

```
C
      READ(IN,*) CEST,CNOR,NAZ,AZBEG,AZINT,NRAD,(RADIL(I),I=1,NRAD)
      NRELIM = NAZ * NRAD
      WRITE(IO,3110) NRELIM,CEST,CNOR,NAZ,AZBEG,AZINT,NRAD,
     1               (RADIL(I), I = 1,NRAD)
      IF (NRELIM .LE. NREMAX) GO TO 460
      WRITE(IO,2040) NRELIM,NREMAX
      ICOND = 21006
      GO TO 999
C
C         READ RECORD TYPE 10 --  POLAR COORDINATE ELEVATIONS.
C
  460 IF (IOPT .EQ. 0) GO TO 520
      READ(IN,*) (ELR(NRE), NRE = 1,NRELIM)
C        NOTE THAT INPUT IS IN FREE FORMAT.
C         THE USER MUST USE CARE TO ORDER THE RECEPTOR ELEVATIONS
C         PROPERLY FOR ALL AZIMUTHS FOR THE FIRST RADIAL, THEN ALL
C         AZIMUTHS FOR EACH SUCCEEDING RADIAL.
C
C         START LOOP TO ENTER RECEPTORS.
C
  520 NRELIM = NRELIM + 1
      IF (NRELIM .LE. NREMAX) GO TO 540
      READ (IN,1020,END=530) DUM
      IF (DUM .EQ. ENDR) GO TO 550
  530 WRITE(IO,2050) NREMAX
      ICOND = 21007
      GO TO 999
C
C         READ RECORD TYPE 11.
C
  540 READ(IN,1050,END=570) (RNAME(J,NRELIM),J=1,2),RREC(NRELIM),
     1                      SREC(NRELIM),ZR(NRELIM),ELR(NRELIM)
C         PLACE 'ENDR' IN COLS 1 TO 4 ON CARD FOLLOWING LAST RECEPTOR
C         TO END READING TYPE 11 RECORDS.
      IF (RNAME(1,NRELIM) .EQ. ENDR) GO TO 550
      GO TO 520
  550 NRELIM = NRELIM - 1
  570 IF (NRELIM .GT. 0) GO TO 580
      WRITE(IO,2060)
      ICOND = 21008
      GO TO 999
C
C         PROCESS RECEPTOR INPUT.
C
  580 CALL TU315(CEST,CNOR,NAZ,AZBEG,AZINT,NRAD,RADIL,ELOW,ELHN)
C
  999 RETURN
C
C         INPUT FORMATS.
C
 1000 FORMAT(20A4/20A4/20A4)
 1010 FORMAT(3A4,2I6)
 1020 FORMAT(A4)
 1030 FORMAT(3A4,7F8.2,F4.0)
 1050 FORMAT(2A4,2F10.3,2F10.0)
C
C         ERROR STATEMENT FORMATS.
C
 2005 FORMAT('0*** CHECK OPTION LIST (I.E., RECORD TYPE 6).',/,
     1       ' *** OPTION INPUT VARIABLES SHOULD BE EITHER 0 OR 1.')
 2010 FORMAT('0*** CONTER VALUE IS OUTSIDE OF RANGE:  ZERO TO ONE.')
 2020 FORMAT('0*** USER TRIED TO INPUT MORE THAN ',I4,' POINT SOURCES.',
     1       ' THIS GOES BEYOND THE CURRENT PROGRAM DIMENSIONS.')
 2030 FORMAT('0*** INPUT DATA INDICATES THAT THERE ARE ',I3,'POINT ',
     1       'SOURCES FOR THIS SIMULATION.')
 2040 FORMAT('0*** TRYING TO GENERATE',I5,' RECEPTORS, BUT ARE ONLY ',
     1       'ALLOWED',I5,'.')
 2050 FORMAT ('0*** USER EITHER TRIED TO INPUT MORE THAN ',I5,
     1        ' RECEPTORS OR ',1H','ENDR',1H',' WAS NOT PLACED AFTER ',
     2          'THE LAST RECEPTOR RECORD.')
 2060 FORMAT ('0*** NO RECEPTORS HAVE BEEN CHOSEN.')
C
C          OUTPUT FORMATS.
C
 3000 FORMAT('0TITLE:  ',20A4,2(/,9X,20A4))
 3010 FORMAT(1H0,31X,'* * * GENERAL INPUT INFORMATION * * *',//,
     1          1X,'THIS SIMULATION FOR THE POLLUTANT ',A4,' BEGINS AT',
     2           ' YEAR: 19',I2,'   JULIAN DAY:',I4,'    HOUR:',I3,' AND',
     3           ' IS FOR',I5,' HOURS.'/,
     4          1X,'A FACTOR OF ',1PE12.6,' HAS BEEN SPECIFIED TO CONVERT',
     5           ' USER LENGTH UNITS TO KILOMETERS.')
 3020 FORMAT(1X,'THIS RUN WILL NOT CONSIDER ANY POLLUTANT LOSS.')
 3030 FORMAT(1X,'A HALF-LIFE OF ',F10.2,' SECONDS HAS BEEN ASSUMED BY',
     1           ' THE USER.')
 3040 FORMAT(1X,'A FACTOR OF ',1PE12.6,' HAS BEEN SPECIFIED TO ',
     1          'CONVERT USER HEIGHT UNITS TO METERS.')
 3050 FORMAT(1H0,'OPTION SPECIFICATION (1 = EMPLOY OPTION;',
     1            ' 0 = DO NOT USE OPTION.)'/,
     2           1X,'OPTION',8X,'MEANING'/,
     3             1X,'NPRNT  ',I4,'     PRINT THIS MANY HOURS OF OUTPUT.'/)
 3060 FORMAT(13X,'TECHNICAL OPTIONS'/,
     1           1X,'IOPT  ',I4,'    USE TERRAIN ADJUSTMENTS.'/,
     2           1X,'IOPB  ',I4,'    USE BUOYANCY-INDUCED DISPERSION.'/,
     3           1X,'IOPD  ',I4,'    NO STACK DOWNWASH.'/,
     4           1X,'IOPG  ',I4,'    NO GRADUAL PLUME RISE.'/
     5           1X,'IOPM  ',I4,'    TEST AGAINST MIXING AT NIGHT.'//,
     6          13X,'INPUT OPTIONS'/,
     7           1X,'IOPQ  ',I4,'    READ HOURLY EMISSIONS ON UNIT 10.'/,
     8           1X,'IOPR  ',I4,'    INPUT RADIAL DISTANCES AND GENERATE ',
     9             'POLAR COORDINATE RECEPTORS.')
 3070 FORMAT(1H0,12X,'OUTPUT OPTIONS'/,
     1           1X,'IOPWPC',I4,'    WRITE PARTIAL CONCENTRATIONS TO UNIT ',
     2             '14.'/)
 3080 FORMAT('0TERRAIN ADJUSTMENTS ARE: ',4F8.3//)
 3090 FORMAT(1H1,'TITLE:  ',20A4,2(/,9X,20A4))
 3100 FORMAT (1H0,27X,'* * * RECEPTOR INFORMATION * * *')
 3110 FORMAT(1H0,'GENERATES',I5,' POLAR COORDINATE RECEPTORS CENTERED ',
     1             'ABOUT (',F9.3,',',F9.3,').'/,
     2          1X,I6,' AZIMUTHS BEGINNING AT',F6.1,' DEGREES, AT ',
     3             'INTERVALS OF',F7.2,' DEGREES.'/,
     4          1X,I6,' RADIAL DIST. (USER UNITS):',12F8.3/,
     5         10X,15F8.3)
      END
C
      SUBROUTINE TU305(METID,MDATAC,MDATBC,ICOND)
C        305-GET-MET-FILE-HEADER
C
C        ARGUMENT LIST:
C          INPUT:    METID  - 8 CHARACTER IDENTIFIER
C                    MDATAC - YR MO DAY OF DATA CREATION (6 DIGITS)
C                    MDATBC - HR MIN SEC OF DATA CREATION (6 DIGITS)
C          OUTPUT:   ICOND  - CONDITION INDICATOR (0 = NO ERROR)
C
C        CALLING ROUTINES:
C          TU210
C
C        SUBPROGRAMS CALLED:
C          TU405
C
C        DESCRIPTION:
C          THIS MODULE CALLS TU405 TO DO THE ACTUAL I/O TO THE MET
C          FILE.  ONLY THE HEADER RECORD IS PROCESSED HERE.  THE
C          METEOROLOGY HEADING REPORT IS PRINTED IN THIS SUBROUTINE.
C          METEOROLOGICAL HEADER RECORD PARAMETERS ARE PASSED THROUGH
C          COMMON METCOM BETWEEN TU305 AND TU405.
C
      PARAMETER (NLMAX=20,NDMAX=40)
      DIMENSION METID(2)
      COMMON /METCOM/DTHDZ(NLMAX),SAL(NLMAX),SEL(NLMAX),TL(NLMAX),
     1                UL(NLMAX),WDL(NLMAX),ZL(NLMAX),KLASS,LMX,MDATA,
     2                MDATB,METNAM(2),MYR,MJD,MHR,ND,NLLIM,DESC(18,NDMAX)TUP06990
      COMMON /INOUT/ IN,IO                                              TUP07000
C                                                                       TUP07010
      KMET = 0                                                          TUP07020
C                                                                       TUP07030
C         READ MET FILE FOR HEADER RECORD.                              TUP07040
C                                                                       TUP07050
      CALL TU405(KMET,ICOND,IEOF,MISG)                                  TUP07060
      IF (ICOND .EQ. 0) GO TO 50                                        TUP07070
      WRITE (IO,1000)                                                   TUP07080
      GO TO 999                                                         TUP07090
   50 IF (IEOF .EQ. 0) GO TO 100                                        TUP07100
      WRITE(IO,1010)                                                    TUP07110
      ICOND = 30501                                                     TUP07120
      GO TO 999                                                         TUP07130
C                                                                       TUP07140
C         MET HEADER RECORD PROCESSED.  COMPARE HEADER RECORD DATA TO   TUP07150
C           THAT EXPECTED.                                              TUP07160
C                                                                       TUP07170
  100 WRITE(IO,1020) METNAM,MDATA,MDATB                                 TUP07180
      WRITE(IO,1030) (DESC(J,1), J = 1,18)                              TUP07190
      IF (ND .EQ. 1) GO TO 110                                          TUP07200
      DO 110 N = 2,ND                                                   TUP07210
         WRITE(IO,1035) (DESC(J,N), J = 1,18)                           TUP07220
  110 CONTINUE                                                          TUP07230
      IF (METNAM(1) .NE. METID(1)) ICOND = 30502                        TUP07240
      IF (METNAM(2) .NE. METID(2)) ICOND = 30503                        TUP07250
      IF (MDATA .NE. MDATAC) ICOND = 30504                              TUP07260
      IF (MDATB .NE. MDATBC) ICOND = 30505                              TUP07270
      IF (ICOND .EQ. 0) GO TO 999                                       TUP07280
      WRITE(IO,1040) METNAM,MDATA,MDATB,METID,MDATAC,MDATBC             TUP07290
C                                                                       TUP07300
  999 RETURN                                                            TUP07310
C                                                                       TUP07320
C         FORMAT STATEMENTS                                             TUP07330
C                                                                       TUP07340
 1000 FORMAT('0*** SYSTEM ERROR ON READING HEADER RECORD OF MET FILE.') TUP07350
 1010 FORMAT('0*** END OF FILE REACHED UPON ATTEMPTING TO READ HEADER ',TUP07360
     1       'RECORD OF MET FILE.')                                     TUP07370
 1020 FORMAT(1H0,'MET FILE IDENTIFIER:  ',2A4,/,                        TUP07380
     1       1X,'CREATED:  ',I6,' (YR MO DAY)',5X,I6,' (HR MIN SEC)')   TUP07390
 1030 FORMAT(1X,'DESCRIPTION:  ',18A4)                                  TUP07400
 1035 FORMAT(1X,14X,18A4)                                               TUP07410
 1040 FORMAT('0*** ID FROM MET FILE IS: ',2A4,3X,I6,3X,I6,/             TUP07420
     1       ' *** EXPECTED ID IS:      ',2A4,3X,I6,3X,I6)              TUP07430
      END                                                               TUP07440
C                                                                       TUP07450
      SUBROUTINE TU405(KMET,ICOND,IEOF,MISG)
C        405-READ-MET-FILE                                              TUP07460
C                                                                       TUP07470
C        ARGUMENT LIST:                                                 TUP07480
C          INPUT:   KMET  - READ COUNTER                                TUP07490
C          OUTPUT:  ICOND - CONDITION INDICATOR (0 = NO ERROR)          TUP07500
C                   IEOF  - END OF FILE INDICATOR (1 = END OF FILE)     TUP07510
C                                                                       TUP07520
C        CALLING ROUTINES:                                              TUP07530
C          TU305, TU320                                                 TUP07540
C                                                                       TUP07550
C        DESCRIPTION:                                                   TUP07560
C          THIS MODULE PERFORMS ALL I/O TO THE METEOROLOGY FILE,        TUP07570
C          UNIT 9.  METEOROLOGY DATA IS READ INTO COMMON METCOM.        TUP07580
C          ERRORS ARE INDICATED BY PASSING A NONZERO VALUE THROUGH      TUP07590
C          ICOND.  END OF FILE IS INDICATED BY PASSING A VALUE OF ONE   TUP07600
C          THROUGH IEOF.  KMET IS USED TO RECORD BOTH THE NUMBER OF     TUP07610
C          RECORDS READ AND TO INDICATE THE TYPE OF RECORD BEING READ   TUP07620
C          (HEADER OR HOURLY).                                          TUP07630
C                                                                       TUP07640
C * * *  INPUT FILE (UNIT 9) - METEOROLOGICAL DATA MUST BE ENTERED VIA  TUP07650
C                          THIS FILE.                                   TUP07660
                                                                        TUP07670
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C
C        THIS FILE IS UNFORMATTED.
C
C        THE ASSUMPTION IS MADE HERE THAT THE USER IS DEFINING THE
C         VARIATION OF METEOROLOGICAL PARAMETERS WITH HEIGHT BY
C         INCLUDING SUFFICIENT LEVELS SUCH THAT LINEAR INTERPOLATION
C         WITH HEIGHT BETWEEN LEVELS WILL BE ADEQUATE.
C
C        ANY INFORMATION REQUIRED FOR A HEIGHT BELOW THE HEIGHT OF THE
C         LOWEST LEVEL WILL BE ASSIGNED THE VALUE FOR THE LOWEST LEVEL.
C         SIMILARLY, ANY INFORMATION REQUIRED FOR A HEIGHT ABOVE THE
C         HEIGHT OF THE HIGHEST LEVEL WILL BE ASSIGNED THE VALUE FOR THE
C         HIGHEST LEVEL.
C
C      RECORD 1 -- HEADER RECORD (OCCURS ONCE AT TOP OF FILE)
C
C        METNAM(2)  AN 8 CHARACTER ALPHANUMERIC IDENTIFIER FOR THE MET
C                    DATA.
C        MDATA      DATE-TIME OF DATA CREATION, MO DAY YR (6 DIGITS)
C        MDATB      DATE-TIME OF DATA CREATION, HR MIN SEC (6 DIGITS)
C        ND         NUMBER OF 72 CHARACTER ALPHANUMERIC LINES OF
C                    DESCRIPTION.
C        DESC       ND LINES OF ALPHANUMERIC INFORMATION (72 CHARACTERS
C                    PER LINE) THAT DESCRIBES THE MET DATA.
C
C      RECORD 2 -- REPETITIVE RECORDS ON MET FILE
C
C        MYR        YEAR (2 DIGITS)
C        MJD        JULIAN DAY (3 DIGITS)
C        MHR        HOUR (2 DIGITS)
C        NLLIM      NUMBER OF DATA LEVELS THIS HOUR
C        LMX        THE DATA LEVEL NUMBER OF THE MIXING HEIGHT
C        KLASS      THE STABILITY CATEGORY FOR THIS HOUR
C        ZL         HEIGHT OF EACH LEVEL (METERS ABOVE GROUND)
C        TL         TEMPERATURE (K) FOR EACH LEVEL
C        WDL        WIND DIRECTION (DEGREES AZIMUTH, CLOCKWISE FROM
C                    NORTH) FOR EACH LEVEL
C        UL         WIND SPEED (M/SEC) FOR EACH LEVEL
C        SAL        SIGMA-A STANDARD DEVIATION OF WIND AZIMUTH
C                    (RADIANS) FOR EACH LEVEL
C        SEL        SIGMA-E STANDARD DEVIATION OF WIND ELEVATION ANGLE
C                    (RADIANS) FOR EACH LEVEL
C
      PARAMETER (NLMAX=20,NDMAX=40)
      COMMON /METCOM/DTHDZ(NLMAX),SAL(NLMAX),SEL(NLMAX),TL(NLMAX),
     1               UL(NLMAX),WDL(NLMAX),ZL(NLMAX),KLASS,LMX,MDATA,
     2               MDATB,METNAM(2),MYR,MJD,MHR,ND,NLLIM,DESC(18,NDMAX)
C
      IEOF = 0
C
C          DETERMINE IF THIS IS THE FIRST READ OF MET FILE.
C
      IF (KMET .GT. 0) GO TO 100
C
C          PROCESS HEADER RECORD.
C
      READ(9,ERR=10,END=20) METNAM,MDATA,MDATB,ND,
     1                      ((DESC(I,J), I = 1,18), J = 1,ND)
      GO TO 999
   10 ICOND = 40501
      GO TO 999
   20 IEOF = 1
      GO TO 999
C
C          PROCESS HOURLY RECORDS.
C
  100 READ(9,ERR=110,END=120) MYR,MJD,MHR,NLLIM,LMX,KLASS,(ZL(I),TL(I),
     1                        WDL(I),UL(I),SAL(I),SEL(I), I = 1,NLLIM)
      IF (KLASS.LT.1.OR.KLASS.GT.4) MISG = 100
C
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      GO TO 999
  110 ICOND = 40502
      GO TO 999
  120 IEOF = 1
C
  999 RETURN
      END
C
      SUBROUTINE TU310(ELOW,ELHN)
C        310-PROCESS-SOURCE-INPUT
C
C        ARGUMENT LIST:
C          I/O:     ELOW   - LOWEST GROUND-LEVEL ELEVATION FOR A SOURCE
C                   ELHN   - LOWEST STACK TOP ELEVATION FOR A SOURCE
C
C        CALLING ROUTINES:
C          TU210
C
C        SUBPROGRAMS CALLED:
C          TU410, TU415
C
C        DESCRIPTION:
C          THIS MODULE COORDINATES ALL OF THE CALCULATIONS RELATED TO
C          SOURCE INPUT.  THE ACTUAL CALCULATIONS ARE PERFORMED BY
C          MODULES AT A LOWER LEVEL, AND THE TASK OF THIS MODULE IS
C          PRIMARILY TO COORDINATE THOSE CALCULATIONS.  THIS SUBROUTINE
C          IS EXECUTED ONCE AFTER ALL THE SOURCE RECORDS HAVE BEEN
C          READ BY SUBROUTINE TU210.
C
      PARAMETER (NPTMAX=25)
      DIMENSION ESTIMP(NPTMAX),ESTHGT(NPTMAX)
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT
      COMMON /SORCOM/D(NPTMAX),PNAME(3,NPTMAX),PSH(NPTMAX),QJ(NPTMAX),
     1               QELEV(NPTMAX),QEAST(NPTMAX),QNORD(NPTMAX),
     2               TS(NPTMAX),VS(NPTMAX),IQYR,IQJD,IQHR,NPTLIM,
     3               IMPS(NPTMAX)
C
C        CHARACTERIZE ALL THE SOURCES.  NPT IS A COUNTER FOR POINT
C         SOURCES PROCESSED.
C
      DO 100 NPT = 1,NPTLIM
         CALL TU410(NPT,ELOW,ELHN,ESTIMP,ESTHGT)
  100 CONTINUE
C
C        RANK POINT SOURCES.
C
      IF (NPTLIM .EQ. 1) GO TO 999
      CALL TU415(ESTIMP)
C
  999 RETURN
      END
C
      SUBROUTINE TU410(NPT,ELOW,ELHN,ESTIMP,ESTHGT)
C        410-CHARACTERIZE-SOURCE
C
C        ARGUMENT LIST:
C          INPUT:   NPT    - COUNT OF POINT SOURCE TO BE PROCESSED
C          I/O:     ELOW   - LOWEST GROUND-LEVEL ELEVATION FOR SOURCE
C                   ELHN   - LOWEST STACK TOP ELEVATION FOR SOURCE
C          OUTPUT:  ESTIMP - ESTIMATE OF POTENTIAL IMPACT
C                   ESTHGT - ESTIMATED EMISSION HEIGHT
C
C        CALLING ROUTINES:
C          TU310
C
C        DESCRIPTION:
C          THIS MODULE DETERMINES THE FOLLOWING:
C          -  ELEVATION OF THE LOWEST STACK TOP IN INVENTORY (ELHN),
C         -  GROUND-LEVEL ELEVATION OF THE LOWEST SOURCE IN                TUP09060
C             INVENTORY (ELOW),                                             TUP09070
C         -  BUOYANCY FACTORS, AND                                          TUP09080
C         -  ESTIMATES OF POTENTIAL IMPACTS.                                TUP09090
C                                                                           TUP09100
C        SOURCE DATA IS PASSED THROUGH COMMON SORCOM.  THIS MODULE          TUP09110
C         ALSO PRODUCES A LISTING OF SOURCE INFORMATION.                    TUP09120
C                                                                           TUP09130
      PARAMETER (NPTMAX=25,NREMAX=180)                                      TUP09140
      DIMENSION ESTIMP(NPTMAX),ESTHGT(NPTMAX)                               TUP09150
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,        TUP09160
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,         TUP09170
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT        TUP09180
      COMMON /SORCOM/D(NPTMAX),PNAME(3,NPTMAX),PSH(NPTMAX),QJ(NPTMAX),      TUP09190
     1               QELEV(NPTMAX),QEAST(NPTMAX),QNORD(NPTMAX),             TUP09200
     2               TS(NPTMAX),VS(NPTMAX),IQYR,IQJD,IQHR,NPTLIM,           TUP09210
     3               IMPS(NPTMAX)                                           TUP09220
      COMMON /RECCOM/ELR(NREMAX),PARTC(NREMAX,NPTMAX),PHCHI(NREMAX),        TUP09230
     1               RNAME(2,NREMAX),RREC(NREMAX),SREC(NREMAX),             TUP09240
     2               STAR(2,NREMAX),ZR(NREMAX),NRELIM                       TUP09250
      COMMON /INOUT/ IN,IO                                                  TUP09260
C                                                                           TUP09270
C        CALCULATE ELOW AND ELHN.                                           TUP09280
C                                                                           TUP09290
      TOM = PSH(NPT)/CELM + QELEV(NPT)                                      TUP09300
C        NPT:  KEEPS TRACK OF POINT SOURCE THAT MODULE IS PROCESSING        TUP09310
      IF (TOM .LT. ELHN) ELHN = TOM                                         TUP09320
C        ELHN, ELEVATION OF LOWEST STACK TOP IN INVENTORY                   TUP09330
C         (USER HEIGHT UNITS).                                              TUP09340
      IF (QELEV(NPT) .LT. ELOW) ELOW = QELEV(NPT)                           TUP09350
C        ELOW, ELEVATION OF LOWEST SOURCE GROUND-LEVEL ELEVATION IN         TUP09360
C         INVENTORY (USER HEIGHT UNITS).                                    TUP09370
C                                                                           TUP09380
C        CALCULATE BUOYANCY FACTOR AND ESTIMATE EMISSION HEIGHT.            TUP09390
C         IF STACK GAS TEMPERATURE > 293 K, THEN PLUME IS CONSIDERED        TUP09400
C         BUOYANT.  BUOYANT PLUME RISE FOR LOW WIND SPEEDS IS USED          TUP09410
C         HERE.                                                             TUP09420
C                                                                           TUP09430
      A = D(NPT)                                                            TUP09440
      B = TS(NPT)                                                           TUP09450
      IF (B .GT. 293.) GO TO 100                                            TUP09460
C                                                                           TUP09470
C        NON-BUOYANT PLUME.                                                 TUP09480
C                                                                           TUP09490
      HF = PSH(NPT)                                                         TUP09500
      GO TO 200                                                             TUP09510
C                                                                           TUP09520
C        BUOYANT PLUME.                                                     TUP09530
C                                                                           TUP09540
  100 F = 2.45153 * VS(NPT) * A * A * (B-293.)/B                            TUP09550
      HP = PSH(NPT)                                                         TUP09560
C       CALCULATE UNSTABLE RISE FOR WIND SPEED OF 3 M/S.                    TUP09570
      HF = HP + 30. * (F/3.) ** 0.6                                         TUP09580
C                                                                           TUP09590
C        ESTIMATE POTENTIAL IMPACTS.                                        TUP09600
C                                                                           TUP09610
  200 ESTHGT(NPT) = HF                                                      TUP09620
      ESTIMP(NPT) = QJ(NPT)/(HF * HF)                                       TUP09630
C        Q/H**2 IS USED FOR THIS SCREENING.                                 TUP09640
C                                                                           TUP09650
C       LIST POINT SOURCE INFORMATION.                                      TUP09660
C                                                                           TUP09670
      IF (NPT .GT. 1) GO TO 210                                             TUP09680
      WRITE(IO,1000) LINE1,LINE2,LINE3                                      TUP09690
      WRITE(IO,1010) NPOL                                                   TUP09700
  210 WRITE(IO,1020) NPT,(PNAME(J,NPT), J = 1,3),QEAST(NPT),QNORD(NPT),     TUP09710
     1               QELEV(NPT),QJ(NPT),PSH(NPT),TS(NPT),                   TUP09720
     2               D(NPT),VS(NPT),ESTIMP(NPT),ESTHGT(NPT),F               TUP09730
C                                                                           TUP09740
      RETURN                                                                TUP09750
```

```
C
 1000 FORMAT(1H1,'TITLE:  ',20A4,2(/,9X,20A4))                             TUP09760
 1010 FORMAT (1H0,48X,'* * * POINT SOURCE INFORMATION * * *',//,           TUP09770
     1          1X,18X,'---------COORDINATES--------',25X,'-------STACK ', TUP09780
     2            'PARAMETERS---------     REL POTEN     EFF      BUOY',/,  TUP09790
     3          1X,4X,'SOURCE',15X,'(USER UNITS)            ---EMISSIONS ', TUP09800
     4            '(G/SEC)---',5X,'HGT    TEMP      DIA     VEL      IMP', TUP09810
     5            'ACT         HGT',6X,'FLUX',/,                            TUP09820
     6          1X,2X,'#',2X,'NAME',12X,'EAST    NORTH      ELEV',9X,     TUP09830
     7            5X,A4,'              (M)      (K)      (M)    (M/S)    Q', TUP09840
     8            '/H**2 ',6X,'(M)    M**4/S**3')                          TUP09850
 1020 FORMAT (1X,I3,1X,3A4,1X,3F9.2,F16.2,8X,4F8.2,1PE13.5,0PF9.2,F9.2) TUP09860
      END                                                                 TUP09870
C                                                                         TUP09880
      SUBROUTINE TU415(ESTIMP)
C        415-RANK-POINT-SOURCES                                           TUP09890
C                                                                         TUP09900
C        ARGUMENT LIST:                                                   TUP09910
C          INPUT    ESTIMP -  ESTIMATE OF POTENTIAL IMPACT                TUP09920
C                                                                         TUP09930
C        CALLING ROUTINES:                                                TUP09940
C          TU310                                                          TUP09950
C                                                                         TUP09960
C        DESCRIPTION:                                                     TUP09970
C          THIS MODULE RANKS THE POINT SOURCES AND OUTPUTS A TABLE OF     TUP09980
C          RANKED SOURCES.                                                TUP09990
C                                                                         TUP10000
      PARAMETER (NPTMAX=25)                                               TUP10010
      DIMENSION PSAV(NPTMAX),ESTIMP(NPTMAX)                               TUP10020
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,      TUP10030
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,       TUP10040
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT      TUP10050
      COMMON /SORCOM/D(NPTMAX),PNAME(3,NPTMAX),PSH(NPTMAX),QJ(NPTMAX),    TUP10060
     1               QELEV(NPTMAX),QEAST(NPTMAX),QNORD(NPTMAX),           TUP10070
     2               TS(NPTMAX),VS(NPTMAX),IQYR,IQJD,IQHR,NPTLIM,         TUP10080
     3               IMPS(NPTMAX)                                         TUP10090
      COMMON /INOUT/ IN,IO                                                TUP10100
C                                                                         TUP10110
C        RANK POINT SOURCES.                                              TUP10120
C                                                                         TUP10130
      DO 200 I = 1,NPTLIM                                                 TUP10140
         SIGMAX=-1.0                                                      TUP10150
         DO 100 NPT = 1,NPTLIM                                            TUP10160
            IF (ESTIMP(NPT) .LE. SIGMAX) GO TO 100                        TUP10170
            SIGMAX = ESTIMP(NPT)                                          TUP10180
            LMAX = NPT                                                    TUP10190
  100    CONTINUE                                                         TUP10200
         IMPS(I) = LMAX                                                   TUP10210
C              IMPS:  SOURCE NUMBER IN ORDER OF SIGNIFICANCE.             TUP10220
         PSAV(I) = SIGMAX                                                 TUP10230
C              PSAV:  POTENTIAL IMPACT IN ORDER OF SIGNIFICANCE.          TUP10240
         ESTIMP(LMAX) = -1.0                                              TUP10250
  200 CONTINUE                                                            TUP10260
C                                                                         TUP10270
C        IF THERE IS MORE THAN ONE SOURCE, THEN OUTPUT TABLE OF           TUP10280
C         RANKED SOURCES.                                                 TUP10290
C                                                                         TUP10300
      IF (NPTLIM .EQ. 1) GO TO 999                                        TUP10310
      WRITE(IO,1000) NPOL                                                 TUP10320
      DO 250 I = 1,NPTLIM                                                 TUP10330
         WRITE(IO,1010) I,IMPS(I),PSAV(I)                                 TUP10340
  250 CONTINUE                                                            TUP10350
C                                                                         TUP10360
  999 RETURN                                                              TUP10370
C                                                                         TUP10380
C         FORMAT STATEMENTS                                               TUP10390
C                                                                         TUP10400
 1000 FORMAT(1H0,47X,'* * * RANKED ',A4,' POINT SOURCES * * *',//,        TUP10410
     1          1X,47X,'          SOURCE             REL POTEN',/,        TUP10420
     2          1X,47X,'RANK      NUMBER                                  TUP10430
                   IMPACT')                                               TUP10440
 1010 FORMAT(1X,47X,I3,7X,I3,7X,6PF12.2)
      END
C
      SUBROUTINE TU315(CEST,CNOR,NAZ,AZBEG,AZINT,NRAD,RADIL,ELOW,ELHN)
C        315-PROCESS-RECEPTOR-INPUT
C
C        ARGUMENT LIST:
C          INPUT:   CEST   - EAST COORDINATE ABOUT WHICH POLAR
C                            COORDINATE GRID IS CENTERED (USER UNITS)
C                   CNOR   - NORTH COORDINATE ABOUT WHICH POLAR
C                            COORDINATE GRID IS CENTERED (USER UNITS)
C                   NAZ    - NUMBER OF AZIMUTHS
C                   AZBEG  - BEGINNING AZIMUTH (DEGREES)
C                   AZINT  - AZIMUTH INTERVAL (DEGREES)
C                   NRAD   - NUMBER OF RADIAL DISTANCES
C                   RADIL  - ARRAY OF RADIAL DISTANCES
C                   ELOW   - LOWEST GROUND-LEVEL ELEVATION FOR A SOURCE
C                   ELHN   - LOWEST STACK TOP ELEVATION FOR A SOURCE
C
C        CALLING ROUTINES:
C          TU210
C
C        SUBPROGRAMS CALLED:
C          TU420, TU425
C
C        DESCRIPTION:
C          THIS MODULE IS EXECUTED AFTER ALL RECEPTOR INPUT HAS BEEN
C          READ BY MODULE TU210.  TU315 COORDINATES THE GENERATION OF
C          POLAR RECEPTORS AND THE OUTPUT OF THE RECEPTOR TABLE.
C
      PARAMETER (NRL=15)
      DIMENSION RADIL(NRL)
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT
C
C        DID USER SPECIFY RADIAL RECEPTOR GRID?
C
      IF (IOPR .EQ. 0) GO TO 100
C
C        GENERATE RADIAL RECEPTOR GRID IN TERMS OF CARTESIAN
C         COORDINATES.
C
      CALL TU420(CEST,CNOR,NAZ,AZBEG,AZINT,NRAD,RADIL)
C
C        PRINT OUT TABLE OF RECEPTORS.
C
  100 CALL TU425(ELOW,ELHN)
C
      RETURN
      END
C
      SUBROUTINE TU420(CEST,CNOR,NAZ,AZBEG,AZINT,NRAD,RADIL)
C        420-GENERATE-POLAR-RECEPTORS
C
C        ARGUMENT LIST:
C          INPUT:   CEST  - EAST COORDINATE ABOUT WHICH POLAR COORDINATE
C                             GRID IS CENTERED (USER UNITS)
C                   CNOR  - NORTH COORDINATE ABOUT WHICH POLAR
C                             COORDINATE GRID IS CENTERED (USER UNITS)
C                   NAZ   - NUMBER OF AZIMUTHS
C                   AZBEG - BEGINNING AZIMUTH (DEGREES)
C                   AZINT - AZIMUTH INTERVAL (DEGREES)
C                   NRAD  - NUMBER OF RADIAL DISTANCES
C                   RADIL - ARRAY OF RADIAL DISTANCES
C
C        CALLING ROUTINES:
C          TU315
C
C        DESCRIPTION:
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C          THIS MODULE GENERATES POLAR RECEPTORS IN TERMS OF CARTESIAN  TUP11130
C          COORDINATES.                                                 TUP11140
C                                                                       TUP11150
      PARAMETER (NPTMAX=25,NREMAX=180,NRL=15)                           TUP11160
      DIMENSION RADIL(NRL)                                              TUP11170
      COMMON /RECCOM/ELR(NREMAX),PARTC(NREMAX,NPTMAX),PHCHI(NREMAX),    TUP11180
     1               RNAME(2,NREMAX),RREC(NREMAX),SREC(NREMAX),         TUP11190
     2               STAR(2,NREMAX),ZR(NREMAX),NRELIM                   TUP11200
C                                                                       TUP11210
      NRE = 0                                                           TUP11220
C        START LOOP OVER RADIALS.                                       TUP11230
      DO 200 I = 1,NRAD                                                 TUP11240
         DUM = RADIL(I)                                                 TUP11250
         AZDUM = AZBEG - AZINT                                          TUP11260
C           START LOOP OVER AZIMUTHS.                                   TUP11270
         DO 100 J = 1,NAZ                                               TUP11280
            NRE = NRE + 1                                               TUP11290
            AZDUM = AZDUM + AZINT                                       TUP11300
            IF (AZDUM .GT. 360.) AZDUM = AZDUM - 360.                   TUP11310
            ADUM = AZDUM * 0.0174533                                    TUP11320
            SINT = SIN(ADUM)                                            TUP11330
            COST = COS(ADUM)                                            TUP11340
            RREC(NRE) = DUM * SINT + CEST                               TUP11350
            SREC(NRE) = DUM * COST + CNOR                               TUP11360
C                                                                       TUP11370
C           THE FOLLOWING TWO EXECUTABLE STATEMENTS USE THE ENCODE      TUP11380
C            ROUTINE AVAILABLE ON THE UNIVAC.  THIS MAY NOT BE          TUP11390
C            AVAILABLE ON OTHER COMPUTERS.  THE FUNCTION OF THIS IS TO  TUP11400
C            PLACE AZIMUTH AND DISTANCE IN THE ALPHANUMERIC NAME FOR    TUP11410
C            THE RECEPTOR SO THAT THIS INFO.  WILL APPEAR ON SOME OF THETUP11420
C            OUTPUT PRINT-OUTS.  SHOULD YOU DECIDE TO PROGRAM AROUND    TUP11430
C            THIS BY MAKING THESE TWO STATEMENTS COMMENT STATEMENTS, THETUP11440
C            RECEPTOR NAMES WILL BE LEFT BLANK ON YOUR OUTPUT.          TUP11450
C                                                                       TUP11460
C           ENCODE THE AZIMUTH (TO THE NEAREST DEGREE) AND THE RADIAL   TUP11470
C            DISTANCE (TO THE NEAREST TENTH OF A USER UNIT) INTO THE TWOTUP11480
C            PORTIONS OF THE ALPHANUMERIC NAME: RNAME.                  TUP11490
C                                                                       TUP11500
            ENCODE(4,1000,RNAME(1,NRE)) AZDUM                           TUP11510
            ENCODE(4,1010,RNAME(2,NRE)) DUM                             TUP11520
            ZR(NRE) = 0.                                                TUP11530
  100    CONTINUE                                                       TUP11540
C           END LOOP OVER AZIMUTHS.                                     TUP11550
  200 CONTINUE                                                          TUP11560
C        END LOOP OVER RADIALS.                                         TUP11570
      RETURN                                                            TUP11580
C                                                                       TUP11590
 1000 FORMAT(F4.0)                                                      TUP11600
 1010 FORMAT(F4.1)                                                      TUP11610
      END                                                               TUP11620
C
      SUBROUTINE TU425(ELOW,ELHN)                                       TUP11630
C        425-PRODUCE-RECEPTOR-TABLE                                     TUP11640
C                                                                       TUP11650
C        ARGUMENT LIST:                                                 TUP11660
C           INPUT:   ELOW   - LOWEST GROUND-LEVEL ELEVATION FOR A SOURCE TUP11670
C                    ELHN   - LOWEST STACK TOP ELEVATION FOR A SOURCE   TUP11680
C                                                                       TUP11690
C        CALLING ROUTINES:                                              TUP11700
C           TU315                                                       TUP11710
C                                                                       TUP11720
C        DESCRIPTION:                                                   TUP11730
C           THIS MODULE COMPILES AND OUTPUTS THE RECEPTOR TABLE WHICH   TUP11740
C           INCLUDES THE RECEPTOR LOCATION, GROUND-LEVEL ELEVATION,     TUP11750
C           AND HEIGHT ABOVE GROUND-LEVEL.                              TUP11760
C                                                                       TUP11770
      PARAMETER (NPTMAX=25,NREMAX=180)                                  TUP11780
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,    TUP11790
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,     TUP11800
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT    TUP11810
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      COMMON /RECCOM/ELR(NREMAX),PARTC(NREMAX,NPTMAX),PHCHI(NREMAX),    TUP11820
     1               RNAME(2,NREMAX),RREC(NREMAX),SREC(NREMAX),         TUP11830
     2               STAR(2,NREMAX),ZR(NREMAX),NRELIM                   TUP11840
      COMMON /INOUT/ IN,IO                                              TUP11850
      DATA STR/'*'/                                                     TUP11860
C                                                                       TUP11870
C         INITIALIZE.                                                   TUP11880
C                                                                       TUP11890
      NRE = 0                                                           TUP11900
      WRITE(IO,1010)                                                    TUP11910
      IDMA = 0                                                          TUP11920
      IDMB = 0                                                          TUP11930
C                                                                       TUP11940
C         PRINT RECEPTOR TABLE.                                         TUP11950
C                                                                       TUP11960
      DO 100 NRE = 1,NRELIM                                             TUP11970
         IF (ELR(NRE) .GE. ELOW) GO TO 10                               TUP11980
         STAR(1,NRE) = STR                                              TUP11990
         IDMA = 1                                                       TUP12000
         GO TO 20                                                       TUP12010
   10    IF (ELR(NRE) .LE. ELHN) GO TO 20                               TUP12020
         STAR(1,NRE) = STR                                              TUP12030
         STAR(2,NRE) = STR                                              TUP12040
         IDMB = 1                                                       TUP12050
   20    IF (NRE/50*50 .NE. NRE) GO TO 30                               TUP12060
         WRITE(IO,1000) LINE1,LINE2,LINE3                               TUP12070
         WRITE(IO,1010)                                                 TUP12080
   30    WRITE (IO,1020) NRE,(RNAME(I,NRE),I = 1,2),RREC(NRE),SREC(NRE),TUP12090
     1                   ELR(NRE),STAR(1,NRE),STAR(2,NRE),ZR(NRE)       TUP12100
  100 CONTINUE                                                          TUP12110
C                                                                       TUP12120
C         PRINT FOOTNOTES AS REQUIRED.                                  TUP12130
C                                                                       TUP12140
      IF ((IDMA .EQ. 0).AND.(IDMB .EQ. 0)) GO TO 150                    TUP12150
      IF (IDMA .EQ. 1) WRITE(IO,1030)                                   TUP12160
      IF (IDMB .EQ. 1) WRITE(IO,1040)                                   TUP12170
  150 IF (IOPT .EQ. 0) WRITE(IO,1050)                                   TUP12180
      IF (IOPT .EQ. 1) WRITE(IO,1060)                                   TUP12190
C                                                                       TUP12200
      RETURN                                                            TUP12210
C                                                                       TUP12220
C         FORMAT STATEMENTS.                                            TUP12230
C                                                                       TUP12240
 1000 FORMAT(1H1,'TITLE:   ',20A4,2(/,9X,20A4))                         TUP12250
 1010 FORMAT(1H0,'RECEPTOR     IDENTIFICATION     -     ------------COORDI',TUP12260
     1          'NATES------------            HEIGHT ABOVE',/,          TUP12270
     2        1X,45X,'(USER UNITS)',16X,'LOCAL GRD-LVL',/,              TUP12280
     3        1X,38X,'EAST           NORTH          ELEV        (M)')     TUP12290
 1020 FORMAT(1X,I5,10X,2A4,6X,3F13.2,1X,2A1,1X,F9.2)                    TUP12300
 1030 FORMAT(11X,'*  RECEPTOR ELEVATION IS BELOW LOWEST STACK BASE ',   TUP12310
     1          'ELEVATION.')                                           TUP12320
 1040 FORMAT(11X,'** RECEPTOR ELEVATION IS ABOVE LOWEST STACK TOP ',    TUP12330
     1          'ELEVATION.')                                           TUP12340
 1050 FORMAT('0NOTE:  THE TERRAIN OPTION, IOPT, IS NOT BEING USED FOR', TUP12350
     1          ' THIS RUN AND ',/,                                     TUP12360
     2       8X,'GROUND-LEVEL ELEVATIONS (STACK OR RECEPTOR) GIVEN ',   TUP12370
     3          'ON INPUT ARE IGNORED.')                                TUP12380
 1060 FORMAT('0NOTE:  THE TERRAIN OPTION, IOPT, IS BEING USED FOR ',    TUP12390
     1          'THIS RUN.'/,                                           TUP12400
     2       8X,'GROUND-LEVEL ELEVATIONS OF RECEPTORS ARE CONSIDERED',  TUP12410
     3          ' RELATIVE TO STACK BASE ELEVATIONS.'/,                 TUP12420
     4       8X,'THE WAY THE EFFECTIVE HEIGHT COMPUTATION IS AFFECTED', TUP12430
     5          ' IS ALSO DEPENDENT UPON TERRAIN ADJUSTMENT FACTORS.')  TUP12440
      END                                                               TUP12450
C
      SUBROUTINE TU220(ICOND)                                           TUP12460
C        220-EXECUTE-DISPERSION-SIMULATION                              TUP12470
C                                                                       TUP12480
C        PARAMETER LIST:                                                TUP12490
C          OUTPUT:  ICOND - CONDITION INDICATOR (0 = NO ERROR)          TUP12500
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C
C         CALLING ROUTINES:
C           MAIN
C
C         SUBPROGRAMS CALLED:
C           TU320, TU325, TU330, TU335, TU340, CHRON, ICHRON
C
C         DESCRIPTION:
C           THIS MODULE ACCOMPLISHES THE ACTUAL SIMULATION.  TWO OUTPUT
C           FILES CAN BE CREATED BY THIS MODULE.  THEY ARE:
C
C              (1)  HOURLY CONCENTRATIONS. UNIT 12
C              (2)  HOURLY PARTIAL CONCENTRATIONS (OPTIONAL). UNIT 14
C
C          NOTE THAT BECAUSE OF THE ORGANIZATION OF THE PROGRAM
C           (NESTING OF LOOPS, SINCE EACH SOURCE MAY HAVE SOMEWHAT
C           DIFFERENT METEOROLOGY), THE PARTIAL CONCENTRATION FILE
C           GENERATED BY THIS PROGRAM IS ORGANIZED DIFFERENT FROM THAT
C           RESULTING FROM MPTER.
C
C***    OUTPUT FILE (UNIT 12) HOURLY CONCENTRATIONS
C
C       RECORD TYPE 1
C          IFLAGH       FLAG TO INDICATE HOURLY CONCENTRATION FILE; = 12
C
C       RECORD TYPE 2
C          LINE1        80 ALPHANUMERIC CHARACTERS FOR TITLE
C          LINE2        80 ALPHANUMERIC CHARACTERS FOR TITLE
C          LINE3        80 ALPHANUMERIC CHARACTERS FOR TITLE
C
C       RECORD TYPE 3   (MET FILE HEADER RECORD)
C          METNAM       AN 8 CHARACTER ALPHANUMERIC IDENTIFIER FOR THE MET
C                        DATA.
C          MDATA        DATE-TIME OF DATA CREATION.  MO DAY YR (6 DIGITS).
C          MDATB        DATE-TIME OF DATA CREATION.  HR MIN SEC (6 DIGITS).
C          ND           NUMBER OF 72 CHARACTER ALPHANUMERIC LINES OF
C                        DESCRIPTION
C          DESC         ND LINES OF ALPHANUMERIC INFORMATION (72 CHARACTERS
C                        PER LINE) THAT DESCRIBES THE MET DATA
C
C       RECORD TYPE 4
C          NPOL         4 CHARACTER POLLUTANT NAME
C          CONTWO       MULTIPLIER TO CONVERT USER UNITS TO KILOMETERS
C          CELM         MULTIPLIER TO CONVERT USER HEIGHT UNITS TO METERS
C          HAFL         POLLUTANT HALF-LIFE (SECONDS).  AN ENTRY OF ZERO
C                        WILL CAUSE NO POLLUTANT LOSS.
C          NPTLIM       NUMBER OF POINT SOURCES CONSIDERED
C          NRELIM       NUMBER OF RECEPTORS CONSIDERED
C
C       RECORD TYPE 5
C          IOPT         TERRAIN ADJUSTMENT OPTION
C          IOPB         BUOYANCY-INDUCED DISPERSION OPTION
C          IOPD         STACK-TIP DOWNWASH OPTION
C          IOPG         GRADUAL PLUME RISE OPTION
C          IOPM         TEST AGAINST BOUNDARY-LAYER HEIGHT AT NIGHT
C          IOPQ         HOURLY EMISSIONS INPUT OPTION
C          IOPR         POLAR COORDINATE RECEPTOR OPTION
C
C       RECORD TYPE 6 (WRITE IF IOPT = 1)
C          CONTER(4)    TERRAIN ADJUSTMENT FACTORS
C
C       RECORD TYPE 7   -  NPTLIM RECORDS (ONE FOR EACH SOURCE)
C          PNAME        12 CHARACTER SOURCE IDENTIFICATION
C          QEAST        EAST COORDINATE OF SOURCE (USER UNITS)
C          QNORD        NORTH COORDINATE OF SOURCE (USER UNITS)
C          QJ(NPT)      EMISSION RATE (G/SEC) FOR POLLUTANT NPOL
C          PSH          PHYSICAL STACK HEIGHT (M)
C          TS           STACK GAS TEMPERATURE (K)
C          D            STACK DIAMETER (M)
C          VS           STACK GAS EXIT VELOCITY (G/SEC)
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C        QELEV          STACK BASE GROUND-LEVEL ELEVATION (USER HEIGHT
C                        UNITS)
C        IMPS           ARRAY OF SOURCE NUMBERS IN ORDER OF SIGNIFICANCE
C
C     RECORD TYPE 8  -  NRELIM RECORDS (ONE FOR EACH RECEPTOR)
C        RNAME          8 CHARACTER RECEPTOR IDENTIFICATION
C        RREC           EAST COORDINATE OF RECEPTOR (USER UNITS)
C        SREC           NORTH COORDINATE OF RECEPTOR (USER UNITS)
C        ZR             RECEPTOR HEIGHT ABOVE LOCAL GROUND-LEVEL (M)
C        ELR            RECEPTOR GROUND-LEVEL ELEVATION (USER HEIGHT UNITS)
C        STAR           FLAG TO INDICATE RECEPTOR STATUS, I.E.,
C                         *  RECEPTOR ELEVATION IS BELOW LOWEST STACK BASE
C                              ELEVATION
C                         ** RECEPTOR ELEVATION IS ABOVE LOWEST STACK TOP
C                              ELEVATION.
C
C     RECORD TYPES 1-8 OCCUR ONCE AT THE TOP OF THE FILE.
C
C          RECORDS 9, 10, AND 11 ARE REPEATED IN
C           SEQUENCE FOR EACH HOUR.
C
C     RECORD TYPE 9 (ONE FOR EACH HOUR)
C        IYR            2-DIGIT YEAR
C        IDY            JULIAN DAY
C        LH             HOUR
C
C     RECORD TYPE 10 (ONE FOR EACH HOUR)
C        HSAV           EFFECTIVE PLUME HEIGHTS FOR EACH SOURCE
C        DSAV           DISTANCE TO FINAL RISE FOR EACH SOURCE
C
C     RECORD TYPE 11 (ONE FOR EACH HOUR)
C        PHCHI(NRE)     CONCENTRATIONS (G/M**3) AT EACH RECEPTOR
C
C
C***  OUTPUT FILE (UNIT 14) PARTIAL CONCENTRATIONS (CREATED IF IOPWPC=1)
C
C     RECORD TYPE 1
C        IFLAGP         FLAG TO INDICATE PARTIAL CONCENTRATION FILE; = 14
C
C     ***  RECORD TYPES 2-8 ARE IDENTICAL TO THOSE IN THE HOURLY
C          CONCENTRATION FILE (UNIT 12).
C
C     ***  RECORD TYPES 1-8 OCCUR ONCE AT THE TOP OF THE FILE.
C
C          ONE RECORD 9 AND NPTLIM RECORD 10'S ARE
C           WRITTEN EACH HOUR.
C
C     RECORD TYPE 9 (ONE FOR EACH HOUR)
C        IYR            2-DIGIT YEAR
C        IDY            JULIAN DAY
C        LH             HOUR
C
C     RECORD TYPE 10 (ONE FOR EACH SOURCE, FOR EACH HOUR)
C        HSAV (NPT)     EFFECTIVE PLUME HEIGHT
C        DSAV (NPT)     DISTANCE TO FINAL RISE
C        PARTC(NRE)     CONCENTRATIONS (G/M**3) AT EACH RECEPTOR FROM
C                        SOURCE NPT (NRE = 1, NRELIM).
C
      PARAMETER (NLMAX=20,NPTMAX=25,NREMAX=180,NDMAX=40)
      DIMENSION HSAV(NPTMAX),DSAV(NPTMAX),CDUM(NREMAX),
     1          DHDUM(NPTMAX)
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT
      COMMON /METCOM/DTHDZ(NLMAX),SAL(NLMAX),SEL(NLMAX),TL(NLMAX),
     1               UL(NLMAX),WDL(NLMAX),ZL(NLMAX),KLASS,LMX,MDATA,
     2               MDATB,METNAM(2),MYR,MJD,MHR,ND,NLLIM,DESC(18,NDMAX)
      COMMON /SORCOM/D(NPTMAX),PNAME(3,NPTMAX),PSH(NPTMAX),QJ(NPTMAX),
     1               QELEV(NPTMAX),QEAST(NPTMAX),QNORD(NPTMAX),
     2               TS(NPTMAX),VS(NPTMAX),IQYR,IQJD,IQHR,NPTLIM,
     3               IMPS(NPTMAX)
      COMMON /RECCOM/ELR(NREMAX),PARTC(NREMAX,NPTMAX),PHCHI(NREMAX),
     1               RNAME(2,NREMAX),RREC(NREMAX),SREC(NREMAX),
     2               STAR(2,NREMAX),ZR(NREMAX),NRELIM
      COMMON /INOUT/ IN,IO
      DATA IFLAGH,IFLAGP /12,14/
C
C          WRITE HEADER RECORDS FOR HOURLY CONCENTRATION FILE (UNIT 12).
C
      WRITE(12) IFLAGH
      WRITE(12) LINE1,LINE2,LINE3
      WRITE(12) METNAM,MDATA,MDATB,ND,((DESC(I,J), I = 1,18), J = 1,ND)
      WRITE(12) NPOL,CONTWO,CELM,HAFL,NPTLIM,NRELIM
      WRITE(12) IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR
      IF (IOPT .EQ. 1) WRITE(12) (CONTER(I), I = 1,4)
      DO 5 NPT = 1,NPTLIM
    5 WRITE(12) (PNAME(I,NPT), I = 1,3),QEAST(NPT),QNORD(NPT),
     1          QJ(NPT),PSH(NPT),TS(NPT),D(NPT),VS(NPT),
     2          QELEV(NPT),IMPS(NPT)
      DO 10 NRE = 1,NRELIM
         WRITE(12) (RNAME(I,NRE), I = 1,2),RREC(NRE),SREC(NRE),ZR(NRE),
     1             ELR(NRE),(STAR(J,NRE), J = 1,2)
   10 CONTINUE
C
C          WRITE HEADER RECORDS FOR THE PARTIAL CONCENTRATION FILE
C           (UNIT 14).
C
      IF (IOPWPC .EQ. 0) GO TO 20
      WRITE(14) IFLAGP
      WRITE(14) LINE1,LINE2,LINE3
      WRITE(14) METNAM,MDATA,MDATB,ND,((DESC(I,J), I = 1,18), J = 1,ND)
      WRITE(14) NPOL,CONTWO,CELM,HAFL,NPTLIM,NRELIM
      WRITE(14) IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR
      IF (IOPT .EQ. 1) WRITE(14) (CONTER(I), I = 1,4)
      DO 13 NPT = 1,NPTLIM
   13 WRITE(14) (PNAME(I,NPT), I = 1,3),QEAST(NPT),QNORD(NPT),
     1          QJ(NPT),PSH(NPT),TS(NPT),D(NPT),VS(NPT),
     2          QELEV(NPT),IMPS(NPT)
      DO 15 NRE = 1,NRELIM
         WRITE(14) (RNAME(I,NRE), I = 1,2),RREC(NRE),SREC(NRE),ZR(NRE),
     1             ELR(NRE),(STAR(J,NRE), J = 1,2)
   15 CONTINUE
C
C          INITIALIZE PRIOR TO START OF SIMULATION.
C
   20 CALL CHRON(IYRS,IDYS,IHRS,IHRBEG)
      IF (IHRBEG .GT. 0) GO TO 30
      ICOND = 22001
      GO TO 900
   30 IHREX = IHRBEG - 1
      IHREND = IHRBEG + IHLIM - 1
      KMET = 0
      KEMIS = 0
      MYDH = -1
      KMISS = 0
      KINCOM = 0
      NTAH = 0
      NHR = 0
      HMAX = -1.0
      DO 40 NRE = 1,NRELIM
         CDUM(NRE) = -9999.
   40 CONTINUE
      DO 50 NPT = 1,NPTLIM
         DHDUM(NPT) = -9999.
   50 CONTINUE
C
C          INITIALIZE FOR NEXT HOUR.
C
  100 DO 110 NRE = 1,NRELIM
         PHCHI(NRE) = 0.0
  110 CONTINUE
      IHREX = IHREX + 1
      CALL ICHRON(IHREX,IYR,IDY,LH)
      IF ((IYR .GE. 0) .AND. (IDY .GE. 0) .AND. (LH .GE. 0)) GO TO 140
      ICOND = 22002
      GO TO 900
  140 IF (MYDH - IHREX) 150,300,400
C
C          GET MET DATA.
C
  150 MISG = 0
      CALL TU320(IHREX,KMET,MYDH,ICOND,MISG)
      IF (ICOND .NE. 0) GO TO 900
      MIST = MISG
      IF (MYDH - IHREX) 200,300,400
C
C          ERROR READING MET FILE.
C
  200 WRITE(IO,1000) MYDH,IHREX
      ICOND = 22003
      GO TO 900
C
C          HAVE FOUND HOUR OF INTEREST.  CHECK IF MISSING CODE TURNED ON.
C
  300 MISG = MIST
      IF (MISG .GT. 0) GO TO 405
      CTER = CONTER(KLASS)
C
C          GET HOURLY EMISSIONS IF IOPQ = 1
C
      IF (IOPQ .EQ. 0) GO TO 310
      CALL TU325(IHREX,KEMIS,ICOND)
      IF (ICOND .NE. 0) GO TO 900
C
C          CALCULATE CONCENTRATIONS
C
  310 CALL TU330(HSAV,DSAV,MISG)
      IF (MISG .GT. 0) GO TO 405
C
C          MET DATA IS SUFFICIENT TO COMPLETE SIMULATION FOR THIS HOUR.
C            WRITE HOURLY AND PARTIAL CONCENTRATIONS TO APPROPRIATE FILES.
C            INCREMENT COUNTERS.
C
      WRITE(12) IYR,IDY,LH
      WRITE(12) (HSAV(NPT),NPT = 1,NPTLIM),(DSAV(NPT), NPT = 1,NPTLIM)
      WRITE(12) (PHCHI(NRE), NRE = 1,NRELIM)
C
      IF (IOPWPC .EQ. 0) GO TO 320
C
      WRITE(14) IYR,IDY,LH
      DO 320 NPT = 1,NPTLIM
        WRITE(14) HSAV(NPT),DSAV(NPT),(PARTC(NRE,NPT), NRE = 1,NRELIM)
  320 CONTINUE
C
C          KEEP TRACK OF NUMBER OF HOURS CALCULATED.  UPDATE MAXIMUM
C            CONCENTRATION.
C
      NTAH = NTAH + 1
C        NTAH:   TOTAL NUMBER OF HOURS CALCULATED.
      CALL TU335(IYR,IDY,LH,HMAX,IYRMAX,IDYMAX,LHMAX,MAXREC)
      IF (NTAH .GT.NPRNT) GO TO 500
      CALL TU340(IYR,IDY,LH,HSAV,DSAV)
      GO TO 500
C
C          MISSING (MISG = 1) AND INCOMPLETE (MISG > 1) PROCESSING.
C
  400 MISG = 1
C        WRITE HOURLY RECORD, WITH MISG CONC., TO UNIT 12.
  405 WRITE(12) IYR,IDY,LH
      WRITE(12) (DHDUM(NPT),NPT = 1,NPTLIM),(DHDUM(NPT),NPT = 1,NPTLIM)
      WRITE(12) (CDUM(NRE), NRE = 1,NRELIM)
      IF (MISG .GT. 1) GO TO 415
      WRITE(IO,1010) IYR,IDY,LH
      KMISS = KMISS + 1
      GO TO 420
  415 WRITE(IO,1015) IYR,IDY,LH
      KINCOM = KINCOM + 1
  420 IF(IOPWPC .EQ. 0) GO TO 500
C          WRITE NPTLIM PARTIAL CONC. RECORDS, WITH MISG CONC., TO
C            UNIT 14.
      WRITE(14) IYR,IDY,LH
      DO 430 NPT = 1,NPTLIM
         WRITE(14) DHDUM(NPT),DHDUM(NPT),(CDUM(NRE), NRE = 1,NRELIM)
  430 CONTINUE
C
C          CHECK FOR END OF SIMULATION.
C
  500 NHR = NHR + 1
C          NHR:  TOTAL NUMBER OF HOURS CONSIDERED.
      IF (IHREX .NE. IHREND) GO TO 100
C
      WRITE(IO,1030) LINE1,LINE2,LINE3
      WRITE(IO,1040)
      WRITE(IO,1050) NPOL,IYRS,IDYS,IHRS,IYR,IDY,LH
      WRITE(IO,1060) HMAX,IYRMAX,IDYMAX,LHMAX,MAXREC
      WRITE(IO,1070) KMISS,KINCOM,NTAH
C
C          GET NEXT SIMULATION PERIOD.
C
      READ(IN,*,ERR=650,END=900) IYRS,IDYS,IHRS,IHLIM
      GO TO 20
C          ERROR ON READING NEW SIMULATION PERIOD.
  650 ICOND = 22004
      WRITE(IO,1020)
C
C          RETURN SEQUENCE.
C
  900 ENDFILE 12
      ENDFILE 12
      IF (IOPWPC .EQ. 0) GO TO 999
      ENDFILE 14
      ENDFILE 14
  999 RETURN
C
C          FORMAT STATEMENTS.
C
 1000 FORMAT('0*** ERROR READING MET FILE (UNIT 9).')
 1010 FORMAT('0MET DATA FOR YEAR-DAY-HOUR,',I2,'-',I3,'-',I2,', ARE ',
     1       'MISSING.  NO CONCENTRATION CALCULATIONS MADE.')
 1015 FORMAT('0MET DATA FOR YEAR-DAY-HOUR,',I2,'-',I3,'-',I2,', ARE ',
     1       'INCOMPLETE.  NO CONCENTRATION CALCULATIONS MADE.')
 1020 FORMAT('0*** SYSTEM ERROR ON READING INPUT FOR NEXT SIMULATION ',
     1       'PERIOD.')
 1030 FORMAT(1H1,'TITLE:  ',20A4,2(/,9X,20A4))
 1040 FORMAT(1H0,23X,'* * * SIMULATION SUMMARY * * *')
 1050 FORMAT('0MAXIMUM ',A4,'CONCENTRATION FOR THE PERIOD (YR,DAY,HR) ',
     1       I2,'-',I3,'-',I2,' TO ',I2,'-',I3,'-',I2)
 1060 FORMAT(' CONCENTRATION:',6PF10.2,/,
     1       ' DATE:             ',I2,'-',I3,'-',I2,/,
     2       ' RECEPTOR NUMBER:  ',I6,//)
 1070 FORMAT('0NUMBER OF HOURLY MET RECORDS MISSING:      ',I6,/,
     1       ' NUMBER OF HOURLY MET RECORDS INCOMPLETE:   ',I6,/,
     2       ' CONCENTRATION ESTIMATES WERE MADE FOR:     ',I6,' HRS')
      END
C
      SUBROUTINE TU320(IHREX,KMET,MYDH,ICOND,MISG)
C        320-GET-MET-DATA
C
C        ARGUMENT LIST:
C          INPUT:   IHREX - SIMULATED HOUR
```

```
C           I/O:     KMET  - MET FILE READ COUNTER
C           OUTPUT:  MYDH  - HOUR READ FROM MET FILE
C                    ICOND - CONDITION INDICATOR (0 = NO ERROR)
C                    MISG  - MISSING CODE (1 = MISSING)
C
C         CALLING ROUTINES:
C           TU220
C
C         SUBPROGRAMS CALLED:
C           TU405, CHRON
C
C         DESCRIPTION:
C           THIS MODULE CALLS TU405 TO DO THE ACTUAL I/O TO THE MET FILE.
C           THE MET FILE IS READ UNTIL THE SIMULATED HOUR (IHREX) IS
C           FOUND.  METEOROLOGICAL DATA VALUES ARE PASSED THROUGH COMMON
C           METCOM BETWEEN TU320 AND TU410.
C
      PARAMETER (NLMAX=20,NDMAX=40)
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT
      COMMON /METCOM/DTHDZ(NLMAX),SAL(NLMAX),SEL(NLMAX),TL(NLMAX),
     1               UL(NLMAX),WDL(NLMAX),ZL(NLMAX),KLASS,LMX,MDATA,
     2               MDATB,METNAM(2),MYR,MJD,MHR,ND,NLLIM,DESC(18,NDMAX)
      COMMON /INOUT/ IN,IO
C
      MISG = 0
C
C          READ HOURLY MET RECORDS.
C
   10 KMET = KMET + 1
      CALL TU405(KMET,ICOND,IEOF,MISG)
      IF (ICOND .EQ. 0) GO TO 100
      WRITE(IO,1000) KMET
      GO TO 999
C
C          NO ERROR ON READ.  CHECK FOR END OF FILE.
C
  100 IF (IEOF .EQ. 0) GO TO 200
      WRITE(IO,1010) KMET-1
      ICOND = 32001
      GO TO 999
C
C          HOURLY RECORD READ SUCCESSFULLY.  IS IT HOUR OF INTEREST?
C
  200 CALL CHRON(MYR,MJD,MHR,MYDH)
      IF (MYDH .GT. 0) GO TO 210
      ICOND = 32002
      GO TO 999
  210 IF (MYDH .LT. IHREX) GO TO 10
C
C          HAVE LOCATED MET DATA FOR THE SIMULATED HOUR OR A LATER HOUR.
C           CHECK TO SEE IF MIXING LEVEL IS TOO HIGH.
C
      IF (LMX .LE. NLLIM) GO TO 300
      WRITE(IO,1020) MYR,MJD,MHR
      MISG = 5
      GO TO 999
C
C          CHECK TO SEE THAT LEVEL HEIGHTS ARE IN ASCENDING ORDER.
C           RETURN TO CALLING ROUTINE IF DATA PASSED SCREENING.
C
  300 DO 310 NL = 2,NLLIM
         IF (ZL(NL) .LE. ZL(NL-1)) GO TO 320
  310 CONTINUE
      GO TO 999
  320 WRITE(IO,1030) MYR,MJD,MHR
      MISG = 10
C
  999 RETURN
```

```
C
C         FORMAT STATEMENTS.
C
 1000 FORMAT('0*** SYSTEM ERROR OCCURRED WHEN READING THE ',I6,'TH ',
     1       'HOURLY MET RECORD.')
 1010 FORMAT('0*** ',I6,' HOURLY MET RECORDS WERE READ.'/,
     1       ' *** THE MET FILE WAS EXHAUSTED WITHOUT FINDING DATA ',
     2       'FOR THE HOUR REQUESTED.')
 1020 FORMAT('0*** THE LEVEL OF THE MIXING HEIGHT EXCEEDS THE NUMBER ',
     1       'OF LEVELS FURNISHED.'/,
     2       ' *** YEAR-DAY-HOUR = ',I2,'-',I3,'-',I2,' IS CONSIDERED',
     3       ' MISSING.')
 1030 FORMAT('0*** HEIGHTS OF LEVELS ARE NOT IN ASCENDING ORDER.'/,
     1       ' *** YEAR-DAY-HOUR = ',I2,'-',I3,'-',I2,' IS CONSIDERED',
     2       ' MISSING.')
      END
C
      SUBROUTINE TU325(IHREX,KEMIS,ICOND)
C        325-GET-HOURLY-EMISSIONS
C
C        ARGUMENT LIST:
C          INPUT:   IHREX - SIMULATED HOUR
C          I/O:     KEMIS - EMISSION FILE READ COUNTER
C          OUTPUT:  ICOND - CONDITION INDICATOR (0 = NO ERROR)
C
C        CALLING ROUTINES:
C          TU220
C
C        SUBPROGRAMS CALLED:
C          TU430, CHRON
C
C        DESCRIPTION:
C          THE TASK OF THIS MODULE IS TO POSITION THE EMISSIONS FILE
C          FOR THE START OF THE RUN.  THE ACTUAL I/O TO THE EMISSIONS
C          FILE IS DONE BY MODULE TU430.  EMISSIONS DATA ARE ACCESSED
C          THROUGH COMMON SORCOM.  ERROR MESSAGES ARE PRINTED BY THIS
C          MODULE, BUT PROGRAM TERMINATION IS INDICATED BY PASSING A
C          NONZERO VALUE THROUGH ICOND.
C
      PARAMETER (NPTMAX=25)
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT
      COMMON /SORCOM/D(NPTMAX),PNAME(3,NPTMAX),PSH(NPTMAX),QJ(NPTMAX),
     1               QELEV(NPTMAX),QEAST(NPTMAX),QNORD(NPTMAX),
     2               TS(NPTMAX),VS(NPTMAX),IQYR,IQJD,IQHR,NPTLIM,
     3               IMPS(NPTMAX)
      COMMON /INOUT/ IN,IO
C
C         READ EMISSIONS FILE.
C
  100 KEMIS = KEMIS + 1
      CALL TU430(ICOND,IEOF)
      IF (ICOND .EQ. 0) GO TO 200
      WRITE(IO,1000) KEMIS
      GO TO 999
C
C         NO ERROR ON READ.  CHECK FOR END OF FILE.
C
  200 IF (IEOF .EQ. 0) GO TO 300
      WRITE(IO,1010) KEMIS - 1
      ICOND = 32501
      GO TO 999
C
C         ONE HOUR OF EMISSIONS DATA READ.  IS IT THE HOUR OF INTEREST?
C
  300 CALL CHRON(IQYR,IQJD,IQHR,IQYDH)
      IF (IQYDH .GT. 0) GO TO 310
      ICOND = 32502
      GO TO 999
  310 IF (IQYDH .EQ. IHREX) GO TO 999
      IF (IQYDH .LT. IHREX) GO TO 100
      WRITE (IO,1020) IQYR,IQJD,IQHR,IYRS,IDYS,IHRS
      ICOND = 32503
C
  999 RETURN
C
C         FORMAT STATEMENTS
C
 1000 FORMAT('0*** SYSTEM ERROR OCCURRED WHEN READING THE ',I6,'TH ',
     1       'HOURLY EMISSION RECORD.')
 1010 FORMAT('0*** ',I6,' HOURLY EMISSION RECORDS WERE READ.'/,
     1       ' *** THE EMISSION FILE WAS EXHAUSTED WITHOUT FINDING ',
     2       'DATA FOR THE HOUR REQUESTED.')
 1020 FORMAT('0*** YEAR-DAY-HOUR READ (',I2,'-',I3,'-',I2,') EXCEEDS',
     1       ' YEAR-DAY-HOUR REQUESTED (',I2,'-',I3,'-',I2,').')
      END
C
      SUBROUTINE TU430(ICOND,IEOF)
C        430-READ-EMISSIONS-FILE
C
C        ARGUMENT LIST:
C          OUTPUT:  ICOND - CONDITION INDICATOR (0 = NO ERROR)
C                   IEOF  - END OF FILE INDICATOR (1 = END OF FILE)
C
C        CALLING ROUTINES:
C          TU325
C
C        DESCRIPTION:
C          THIS MODULE PERFORMS ALL I/O TO THE EMISSIONS FILE, UNIT 10.
C          EMISSIONS DATA ARE READ INTO COMMON SORCOM.  ERRORS ARE
C          INDICATED BY PASSING A NONZERO VALUE THROUGH ICOND.  END OF
C          FILE IS INDICATED BY PASSING A VALUE OF ONE THROUGH IEOF.
C
C***  INPUT FILE (UNIT 10) EMISSION DATA (USED IF IOPQ = 1)
C
C       RECORD TYPE 1 (ONE FOR EACH HOUR OF SIMULATION)
C        IQYR            YEAR
C        IQJD            JULIAN DAY
C        IQHR            HOUR
C        QJ(NPT)         EMISSION RATE FOR THE POLLUTANT NPOL FOR EACH
C                         SOURCE NPT (G/SEC).
C        TS(NPT)         STACK GAS TEMPERATURE (KELVIN) FOR EACH
C                         SOURCE NPT.
C        VS(NPT)         STACK GAS EXIT VELOCITY (M/SEC) FOR EACH
C                         SOURCE NPT.
C
      PARAMETER (NPTMAX=25)
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT
      COMMON /SORCOM/D(NPTMAX),PNAME(3,NPTMAX),PSH(NPTMAX),QJ(NPTMAX),
     1               QELEV(NPTMAX),QEAST(NPTMAX),QNORD(NPTMAX),
     2               TS(NPTMAX),VS(NPTMAX),IQYR,IQJD,IQHR,NPTLIM,
     3               IMPS(NPTMAX)
C
C         READ HOURLY RECORD.
C
      READ(10,ERR=100,END=200) IQYR,IQJD,IQHR,
     1                        (QJ(NPT), NPT = 1, NPTLIM),
     2                        (TS(NPT), NPT = 1, NPTLIM),
     3                        (VS(NPT), NPT = 1, NPTLIM)
      GO TO 999
C
C         ERROR IN READING HOURLY EMISSIONS RECORD.
C
  100 ICOND = 43001
      GO TO 999
C
C         REACHED END OF FILE.
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C
  200 IEOF = 1
C
  999 RETURN
      END
C
      SUBROUTINE TU330(HSAV,DSAV,MISG)
C        330-CALCULATE-CONCENTRATION
C
C        ARGUMENT LIST:
C          OUTPUT:  HSAV  - PLUME HEIGHTS FOR THIS HOUR (METERS)
C                   DSAV  - DISTANCE TO FINAL RISE FOR THIS HOUR
C                   MISG  - MISSING CODE (1 = MISSING)
C
C        CALLING ROUTINES:
C          TU220
C
C        SUBPROGRAMS CALLED:
C          TU435, TU440, TU445, TU450, TU455, ZF
C
C        DESCRIPTION:
C          THIS MODULE COORDINATES THE CONCENTRATION CALCULATIONS WHICH
C          INCLUDES:
C          -  CALCULATING PLUME RISE FOR EACH POINT SOURCE,
C          -  CALCULATING PLUME PENETRATION FOR EACH POINT SOURCE,
C          -  DETERMINING THE METEOROLOGY AT THE EFFECTIVE PLUME
C               HEIGHT FOR EACH POINT SOURCE,
C          -  CALCULATING THE DISPERSION PARAMETERS AT EACH
C               RECEPTOR, AND
C          -  COMPUTING RELATIVE CONCENTRATIONS AT EACH RECEPTOR.
C
C        DEFINITIONS OF IMPORTANT VARIABLES:
C
C        PARTC - HOURLY PARTIAL CONCENTRATION ARRAY.  CONTRIBUTIONS
C                (G/M**3) BY RECEPTOR AND SOURCE.
C        PHCHI - HOURLY CONCENTRATION ARRAY.  TOTAL CONCENTRATIONS
C                (G/M**3) BY RECEPTOR.
C
      PARAMETER (NLMAX=20,NPTMAX=25,NREMAX=180,NDMAX=40)
      DIMENSION HSAV(NPTMAX),DSAV(NPTMAX)
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT
      COMMON /METCOM/DTHDZ(NLMAX),SAL(NLMAX),SEL(NLMAX),TL(NLMAX),
     1               UL(NLMAX),WDL(NLMAX),ZL(NLMAX),KLASS,LMX,MDATA,
     2               MDATB,METNAM(2),MYR,MJD,MHR,ND,NLLIM,DESC(18,NDMAX)
      COMMON /SORCOM/D(NPTMAX),PNAME(3,NPTMAX),PSH(NPTMAX),QJ(NPTMAX),
     1               QELEV(NPTMAX),QEAST(NPTMAX),QNORD(NPTMAX),
     2               TS(NPTMAX),VS(NPTMAX),IQYR,IQJD,IQHR,NPTLIM,
     3               IMPS(NPTMAX)
      COMMON /RECCOM/ELR(NREMAX),PARTC(NREMAX,NPTMAX),PHCHI(NREMAX),
     1               RNAME(2,NREMAX),RREC(NREMAX),SREC(NREMAX),
     2               STAR(2,NREMAX),ZR(NREMAX),NRELIM
C
C        INITIALIZE POTENTIAL TEMPERATURE GRADIENT ARRAY FOR THIS HOUR.
C
      DO 5 NL = 1,NLLIM
         DTHDZ(NL) = 100.
    5 CONTINUE
C
C        BEGIN LOOP OVER SOURCES.
C
      DO 300 NPT = 1,NPTLIM
C
C        CALCULATE PLUME RISE.
C
      CALL TU435(NPT,HL,H,TEMPST,UST,THZST,FO,DELH,DISTF,HE,MISG)
      IF (MISG .GT. 0) GO TO 999
C
C        CALCULATE PARTIAL PLUME PENETRATION.
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C                                                                       TUP18770
      CALL TU440(H,HL,DELH,HEPR,PORT,DELHPR,ZMN)                        TUP18780
      IF (PORT .GT. 0.) GO TO 20                                        TUP18790
C                                                                       TUP18800
C         NONE OF PLUME AVAILABLE FOR MIXING.                           TUP18810
C                                                                       TUP18820
      IF (IOPWPC .EQ. 0) GO TO 300                                      TUP18830
      DO 10 NRE = 1,NRELIM                                              TUP18840
         PARTC(NRE,NPT) = 0.0                                           TUP18850
   10 CONTINUE                                                          TUP18860
      GO TO 300                                                         TUP18870
C                                                                       TUP18880
C         CALCULATE EMISSIONS METEOROLOGY.                              TUP18890
C                                                                       TUP18900
   20 CALL TU445(HEPR,UPL,WDPL,SAPL,SEPL,MISG)                          TUP18910
      IF (MISG .GT. 0) GO TO 999                                        TUP18920
C                                                                       TUP18930
C         CALCULATE DISTANCE TO FINAL RISE.                             TUP18940
C                                                                       TUP18950
      IF (DISTF .EQ. 0) GO TO 25                                        TUP18960
      DISTF = (DELHPR * UST/(160. * FO ** 0.333333)) ** 1.5             TUP18970
C                                                                       TUP18980
C         SET SOURCE PARAMETERS.                                        TUP18990
C                                                                       TUP19000
   25 Q = QJ(NPT) * PORT                                                TUP19010
      RQ = QEAST(NPT)                                                   TUP19020
      SQ = QNORD(NPT)                                                   TUP19030
      EP = QELEV(NPT)                                                   TUP19040
      HSAV(NPT) = HEPR                                                  TUP19050
      DSAV(NPT) = DISTF                                                 TUP19060
      TRAD = WDPL * 0.017453292                                         TUP19070
      SINT = SIN(TRAD)                                                  TUP19080
      COST = COS(TRAD)                                                  TUP19090
C                                                                       TUP19100
      IF (IOPT .EQ. 0) GO TO 110                                        TUP19110
C                                                                       TUP19120
C         CONCENTRATION CALCULATIONS -- TERRAIN CASE.                   TUP19130
C                                                                       TUP19140
      DO 100 NRE = 1,NRELIM                                             TUP19150
C         BEGIN LOOP OVER RECEPTORS.                                    TUP19160
      HTEMP = HEPR                                                      TUP19170
C         INITIALIZING HTEMP AGAIN IN CASE MODIFIED BY TERRAIN OR       TUP19180
C           GRADUAL RISE.                                               TUP19190
      PARTC(NRE,NPT) = 0.0                                              TUP19200
      ER = ELR(NRE)                                                     TUP19210
      Z = ZR(NRE)                                                       TUP19220
      IF (KLASS .EQ. 4) GO TO 30                                        TUP19230
      IF (Z .GT. HL) GO TO 100                                          TUP19240
   30 XDUM = RQ - RREC(NRE)                                             TUP19250
      YDUM = SQ - SREC(NRE)                                             TUP19260
      X = (YDUM * COST + XDUM * SINT) * CONTWO                          TUP19270
      IF (X .LE. 0.) GO TO 100                                          TUP19280
      Y = (YDUM * SINT - XDUM * COST) * CONTWO                          TUP19290
      DELH = DELHPR                                                     TUP19300
C         MUST RESET PLUME RISE HERE SINCE MAY HAVE MODIFIED (FOURTH    TUP19310
C         EXECUTABLE STATEMENT DOWN) FOR LAST RECEPTOR.                 TUP19320
      IF (X .GE. DISTF) GO TO 50                                        TUP19330
      IF ((IOPB .EQ. 0) .AND. (IOPG .EQ. 1)) GO TO 50                   TUP19340
C         RECALCULATE PLUME RISE IF EITHER GRADUAL RISE OR BID.         TUP19350
      DLHG = 160. * FO ** 0.333333 * X ** 0.666667/UST                  TUP19360
      IF (DELH .GT. DLHG) DELH = DLHG                                   TUP19370
      IF (IOPG .EQ. 1) GO TO 50                                         TUP19380
C         MODIFY PLUME HEIGHT ONLY IF USING GRADUAL RISE.               TUP19390
      HTEMP = H + DELH                                                  TUP19400
      ZMN = HTEMP                                                       TUP19410
      IF (KLASS .GT. 2) GO TO 50                                        TUP19420
      IF (HL - HTEMP .LT. ZMN) ZMN = HL - HTEMP                         TUP19430
C         MODIFY H FOR TERRAIN.                                         TUP19440
   50 DUM = ER - EP                                                     TUP19450
      HTEMP = HTEMP + CELM * (CTER * DUM - DUM)                         TUP19460
      RC = 0.0
      IF (X .LT. 0.001) GO TO 60
      IF (HTEMP.LT.0.) HTEMP = 0.
C
C         CALCULATE DISPERSION PARAMETERS.
C
      CALL TU450(X,UPL,SAPL,SEPL,DELH,SY,SZ)
C
C         CALCULATE RELATIVE CONCENTRATION.
C
      CALL TU455(Y,Z,HTEMP,SY,SZ,HL,UST,RC)
      DA = SZ/ZMN
      Z = ZF(DA) * ZMN
      CALL TU455(Y,Z,ZMN,SY,SZ,HL,UST,RCT)
      IF (RCT .LT. RC) RC = RCT
C
C         CALCULATE ABSOLUTE CONCENTRATION.  INCLUDE EXPONENTIAL
C           POLLUTANT LOSS.  UNITS OF CONCENTRATION ARE G/M**3.
C
   60 TT = X/UPL
C           TT:  TRAVEL TIME IN SEC-KM/M.
      PROD = RC * Q/EXP(TT * TLOS)
      PHCHI(NRE) = PHCHI(NRE) + PROD
      PARTC(NRE,NPT) = PROD
  100 CONTINUE
C         END OF LOOP FOR RECEPTORS.
      GO TO 300
C
C         CONCENTRATION CALCULATIONS -- NO TERRAIN.
C
  110 DO 200 NRE = 1,NRELIM
C         BEGIN LOOP OVER RECEPTORS.
      HTEMP = HEPR
C         INITIALIZING HTEMP AGAIN IN CASE MODIFIED BY GRADUAL RISE.
      PARTC(NRE,NPT) = 0.0
      Z = ZR(NRE)
      IF (KLASS .EQ. 4) GO TO 130
      IF (Z .GT. HL) GO TO 200
  130 XDUM = RQ - RREC(NRE)
      YDUM = SQ - SREC(NRE)
      X = (YDUM * COST + XDUM * SINT) * CONTWO
      IF (X .LE. 0.) GO TO 200
      Y = (YDUM * SINT - XDUM * COST) * CONTWO
      DELH = DELHPR
C         MUST RESET PLUME RISE HERE SINCE MAY HAVE MODIFIED (FOURTH
C         EXECUTABLE STATEMENT DOWN) FOR LAST RECEPTOR.
      IF (X .GE. DISTF) GO TO 150
      IF ((IOPB .EQ. 0) .AND. (IOPG .EQ. 1)) GO TO 150
C         RECALCULATE PLUME RISE IF EITHER GRADUAL RISE OR BID.
      DLHG = 160. * FO ** 0.333333 * X ** 0.666667/UST
      IF (DELH .GT. DLHG) DELH = DLHG
      IF (IOPG .EQ. 1) GO TO 150
C         MODIFY PLUME HEIGHT ONLY IF USING GRADUAL RISE.
      HTEMP = H + DELH
  150 RC = 0.0
      IF (X .LT. 0.001) GO TO 160
C
C         CALCULATE DISPERSION PARAMETERS.
C
      CALL TU450(X,UPL,SAPL,SEPL,DELH,SY,SZ)
C
C         CALCULATE RELATIVE CONCENTRATION.
C
      CALL TU455(Y,Z,HTEMP,SY,SZ,HL,UST,RC)
C
C         CALCULATE ABSOLUTE CONCENTRATION.  INCLUDE EXPONENTIAL
C           POLLUTANT LOSS.  UNITS OF CONCENTRATION ARE G/M**3.
C
  160 TT = X/UPL
C           TT:  TRAVEL TIME IN SEC-KM/M.
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```
      PROD = RC * Q/EXP(TT * TLOS)
      PHCHI(NRE) = PHCHI(NRE) + PROD
      PARTC(NRE,NPT) = PROD
  200 CONTINUE
C          END OF LOOP FOR RECEPTORS.
  300 CONTINUE
C          END OF LOOP FOR SOURCES.
  999 RETURN
      END
C
      SUBROUTINE TU435(NPT,HL,H,TEMPST,UST,THZST,FO,DELH,DISTF,HE,MISG)
C        435-LAYER-BY-LAYER-PLUME-RISE
C
C           ARGUMENT LIST:
C             INPUT:    NPT    - SOURCE NUMBER
C             OUTPUT:   HL     - MIXING HEIGHT (METERS)
C                       H      - PHYSICAL STACK HEIGHT (METERS)
C                       TEMPST - AMBIENT AIR TEMPERATURE AT STACK TOP (K)
C                       UST    - WIND SPEED AT STACK TOP (M/SEC)
C                       THZST  - POTENTIAL TEMPERATURE OF LAYER CONTAINING
C                                  STACK
C                       FO     - INITIAL BUOYANCY FLUX (M**4/S**3)
C                       DELH   - PLUME RISE (METERS)
C                       DISTF  - DISTANCE TO FINAL RISE
C                       HE     - EFFECTIVE PLUME HEIGHT (METERS)
C                       MISG   - MISSING CODE (IF MISG > 0 THEN MISSING)
C
C           CALLING ROUTINES:
C             TU330
C
C           SUBPROGRAMS CALLED:
C             TU510, TU515, TU520, TU530, TU540, TU550
C
C           DESCRIPTION:
C             PLUME RISE IS CALCULATED THROUGH EACH VERTICAL LAYER TAKING
C             INTO ACCOUNT THE VARIATION OF METEOROLOGICAL INFORMATION
C             WITH HEIGHT (SPECIFICALLY, TEMPERATURE AND WIND SPEED).  IT
C             IS ASSUMED THAT THE METEOROLOGICAL INFORMATION IS SUFFI-
C             CIENTLY DENSE IN THE VERTICAL SO THAT LINEAR INTERPOLATION
C             OF THE PARAMETERS BETWEEN LEVELS YIELDS REASONABLE VALUES.
C
      PARAMETER (NLMAX=20,NPTMAX=25,NDMAX=40)
      DIMENSION ZTOP(NLMAX)
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT
      COMMON /METCOM/DTHDZ(NLMAX),SAL(NLMAX),SEL(NLMAX),TL(NLMAX),
     1               UL(NLMAX),WDL(NLMAX),ZL(NLMAX),KLASS,LMX,MDATA,
     2               MDATB,METNAM(2),MYR,MJD,MHR,ND,NLLIM,DESC(18,NDMAX)
      COMMON /SORCOM/D(NPTMAX),PNAME(3,NPTMAX),PSH(NPTMAX),QJ(NPTMAX),
     1               QELEV(NPTMAX),QEAST(NPTMAX),QNORD(NPTMAX),
     2               TS(NPTMAX),VS(NPTMAX),IQYR,IQJD,IQHR,NPTLIM,
     3               IMPS(NPTMAX)
      DATA AMISG/-9999./
C
C          INITIALIZE.
C
      MISG = 0
      DISTF = 5000.
      DO 10 NL = 1,NLLIM
         ZTOP(NL) = 0.0
   10 CONTINUE
      HL = ZL(LMX)
      H = PSH(NPT)
C
C          FIND HEIGHT ABOVE STACK TOP OF EACH LEVEL.
C
      DO 30 NL = 1,NLLIM
         ZTOP(NL) = ZL(NL) - H
C             ZTOP HAS INDEX OF EACH LEVEL.
```

```
   30 CONTINUE
C
      IF (H .LT. ZL(NLLIM)) GO TO 45
C
C         PHYSICAL STACK HEIGHT IS ABOVE OR EQUAL TO HIGHEST DATA LEVEL.
C
      UST = UL(NLLIM)
      IDUM = 20
      IF (UST .EQ. AMISG) GO TO 900
      TEMPST = TL(NLLIM)
      IDUM = 30
      IF (TEMPST .EQ. AMISG) GO TO 900
      IBOT = NLLIM - 1
      ITOP = NLLIM
      IF (DTHDZ(IBOT) .NE. 100.) GO TO 40
C
      CALL TU510(IBOT,ITOP,MISG)
      IF (MISG .GT. 0) GO TO 999
C
   40 THZST = DTHDZ(IBOT)
      IBOT = NLLIM
      GO TO 100
C
   45 IF (H .GT. ZL(1)) GO TO 60
C
C         PHYSICAL STACK HEIGHT IS BELOW OR EQUAL TO LOWEST DATA LEVEL.
C
      UST = UL(1)
      IDUM = 70
      IF (UST .EQ. AMISG) GO TO 900
      TEMPST = TL(1)
      IDUM = 80
      IF (TEMPST .EQ. AMISG) GO TO 900
      IBOT = 1
      ITOP = 2
      IF (DTHDZ(IBOT) .NE. 100.) GO TO 50
C
      CALL TU510(IBOT,ITOP,MISG)
      IF (MISG .GT. 0) GO TO 999
C
   50 THZST = DTHDZ(IBOT)
      IBOT = 0
      ITOP = 1
      GO TO 100
C
C         PHYSICAL STACK HEIGHT IS BETWEEN LOWEST & HIGHEST DATA LEVELS.
C
   60 NL = 0
   70 NL = NL + 1
      IF (ZTOP(NL) .LE. 0.) GO TO 70
C
C         HAVE FOUND LAYER OF STACK.
C
      ITOP = NL
      IBOT = ITOP - 1
      ZLYR = ZL(ITOP) - ZL(IBOT)
      FRACT = (H - ZL(IBOT))/ZLYR
      IDUM = 90
      IF (TL(IBOT) .EQ. AMISG) GO TO 900
      IDUM = 100
      IF (TL(ITOP) .EQ. AMISG) GO TO 900
      TEMPST = TL(IBOT) + FRACT * (TL(ITOP) - TL(IBOT))
      IDUM = 110
      IF (UL(IBOT) .EQ. AMISG) GO TO 900
      IDUM = 120
      IF (UL(ITOP) .EQ. AMISG) GO TO 900
      UST = UL(IBOT) + FRACT * (UL(ITOP) - UL(IBOT))
      IF (DTHDZ(IBOT) .NE. 100.) GO TO 80
C
      CALL TU510(IBOT,ITOP,MISG)
      IF (MISG .GT. 0) GO TO 999
C
   80 THZST = DTHDZ(IBOT)
C
C          IF STACK DOWNWASH IS TO BE CONSIDERED, COMPUTE ITS VALUE.
C
  100 IF (IOPD .EQ. 1) GO TO 110
      CALL TU515(NPT,TEMPST,UST,FDW)
      IF (FDW .GT. 0.) GO TO 110
      DELH = 0.
      GO TO 990
C
C          DETERMINE THE INITIAL BUOYANCY FLUX, FO.
C
  110 FO = 9.806*VS(NPT)*D(NPT)*D(NPT) * (TS(NPT)-TEMPST)/(4.*TS(NPT))
      F = FO
C
C          CALCULATE UNSTABLE-NEUTRAL MOMENTUM RISE FOR LATER COMPARISON
C
      DELHUM = 3. * D(NPT) * VS(NPT)/UST
C
C          IS THE LAYER CONTAINING THE STACK STABLE?
C
      IF (THZST .GT. 0.001) GO TO 200
C
C          THE LAYER CONTAINING THE STACK IS UNSTABLE-NEUTRAL.
C           CALCULATE BUOYANCY RISE.
C
      CALL TU520(F,UST,H,IB,DELH)
C
C          IF UNSTABLE-NEUTRAL MOMENTUM RISE (DELHUM) EQUALS OR EXCEEDS
C           UNSTABLE-NEUTRAL BUOYANCY RISE (DELH) THEN MOMENTUM RISE
C           APPLIES.
C
      IF (DELH .GT. DELHUM) GO TO 120
      DISTF = 0.
      DELH = DELHUM
      GO TO 990
C
C          IF AT THE TOP LEVEL OR IF PLUME RISE IS LESS THAN OR EQUAL TO
C            THE TOP OF THE LAYER CONTAINING THE STACK THEN THE FINAL
C            RISE HAS BEEN FOUND.
C
  120 IF (IBOT .EQ. NLLIM) GO TO 990
      IF (DELH .LE. ZTOP(ITOP)) GO TO 990
      IF (ITOP .EQ. 1) GO TO 130
C
C          UNSTABLE-NEUTRAL PLUME RISE EXTENDS INTO NEXT LEVEL, REPEAT
C           INITIAL PLUME RISE ESTIMATE USING AVERAGE METEOROLOGY.
C
      T = TEMPST
      U = UST
      T = (T + TL(ITOP))/2.
      U = (U + UL(ITOP))/2.
C         THZST WILL STAY THE SAME
      CALL TU520(F,U,H,IB,DELH)
      IF (DELH .LE. ZTOP(ITOP)) GO TO 990
C
  130 ZT = ZTOP(ITOP)
C
C          DETERMINE UNSTABLE-NEUTRAL RESIDUAL BUOYANCY.
C           BRANCH TO CONSIDER NEXT LAYER.
C
      CALL TU530(U,H,IB,DELH,ZT,FR)
      GO TO 300
C
C          LAYER CONTAINING STACK IS STABLE.  CALCULATE STABLE MOMENTUM
C            RISE (DELHSM).
C
  200 ZB = 0.
```

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      DELHSM = 0.646 * (VS(NPT)*VS(NPT)*D(NPT)*D(NPT)/(TS(NPT)*UST))**
     1         0.333333 * TEMPST**0.5/THZST**0.166667
C
C          CHOOSE LOWEST OF THE MOMENTUM RISES.
C
      IF (DELHUM .LT. DELHSM) DELHSM = DELHUM
C
C          CALCULATE STABLE RISE.
C
      CALL TU540(FO,F,UST,TEMPST,THZST,ZB,IS,DELH)
C
C          CHECK AGAINST MOMENTUM RISE.
C
      IF (DELH .GT. DELHSM) GO TO 210
      DELH = DELHSM
      DISTF = 0.
      GO TO 990
C
C          IF AT THE TOP LEVEL OR IF PLUME RISE IS LESS THAN OR EQUAL TO
C           THE TOP OF THE LAYER CONTAINING THE STACK THEN THE FINAL
C           RISE HAS BEEN FOUND.
C
  210 IF (IBOT .EQ. NLLIM) GO TO 990
      DELHT = DELH * 1.5
      IF (DELHT .LE. ZTOP(ITOP)) GO TO 990
      IF (ITOP .EQ. 1) GO TO 220
C
C          STABLE PLUME RISE EXTENDS INTO NEXT LEVEL, REPEAT INITIAL
C           PLUME RISE ESTIMATE USING AVERAGE METEOROLOGY.
C
      T = TEMPST
      U = UST
      T = (T + TL(ITOP))/2.
      U = (U + UL(ITOP))/2.
C          THZST WILL REMAIN THE SAME
      CALL TU540(FO,F,U,T,THZST,ZB,IS,DELH)
      DELHT = DELH * 1.5
      IF (DELHT .LE. ZTOP(ITOP)) GO TO 990
C
  220 ZT = ZTOP(ITOP)
C
C          DETERMINE STABLE RESIDUAL BUOYANCY.
C
      CALL TU550(FO,F,U,T,THZST,ZB,ZT,IS,FR)
C
C          CONSIDER NEXT LAYER.
C
  300 IBOT = IBOT + 1
C          CHECK TO SEE IF NEW BOTTOM IBOT = NLLIM
      IF (IBOT .NE. NLLIM) GO TO 310
      U = UL(IBOT)
      DTHDZ(IBOT) = DTHDZ(IBOT-1)
      T = TL(IBOT)
      GO TO 320
  310 ITOP = ITOP + 1
      IDUM = 130
      IF (UL(ITOP) .EQ. AMISG) GO TO 900
      U = (UL(ITOP) + UL(IBOT))/2.
      IDUM = 140
      IF (TL(ITOP) .EQ. AMISG) GO TO 900
      T = (TL(ITOP) + TL(IBOT))/2.
      IF (DTHDZ(IBOT) .NE. 100.) GO TO 320
C
      CALL TU510(IBOT,ITOP,MISG)
      IF (MISG .GT. 0) GO TO 999
C
  320 THZ = DTHDZ(IBOT)
      F = FR
      ZB = ZTOP(IBOT)
      ZT = ZTOP(ITOP)
```

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C
C         IS THIS LAYER STABLE?
C
      IF (THZ .GT. 0.001) GO TO 400
C
C         LAYER IS UNSTABLE-NEUTRAL.
C
      CALL TU520(F,U,H,IB,DELH)
      DELH = DELH + ZB
      IF (IBOT .EQ. NLLIM) GO TO 990
      IF (DELH .LE. ZT) GO TO 990
C
C         PLUME RISE EXCEEDS LAYER, FIND UNSTABLE-NEUTRAL RESIDUAL
C           BUOYANCY AND REPEAT FOR NEXT LAYER.
C
      CALL TU530(U,H,IB,DELH,ZT,FR)
      GO TO 300
C
C         THIS LAYER IS STABLE.  CALCULATE STABLE RISE.
C
  400 CALL TU540(FO,F,U,T,THZ,ZB,IS,DELH)
      IF (IBOT .EQ. NLLIM) GO TO 990
      DELHT = DELH * 1.5
      IF (DELHT .LE. ZT) GO TO 990
C
C         PLUME RISE EXCEEDS LAYER, FIND STABLE RESIDUAL BUOYANCY
C           AND REPEAT FOR NEXT LAYER.
C
      CALL TU550(FO,F,U,T,THZ,ZB,ZT,IS,FR)
      GO TO 300
C
C         MISSING PROCESSING.
C
  900 MISG = IDUM
      GO TO 999
C
C         RETURN SEQUENCE.
C
  990 DELH = DELH * FDW
      HE = H + DELH
  999 RETURN
      END
C
      SUBROUTINE TU510(IBOT,ITOP,MISG)
C        510-CALCULATE-POTENTIAL-TEMPERATURE-GRADIENT
C
C         ARGUMENT LIST:
C           INPUT:    IBOT - NUMBER OF BOTTOM LEVEL OF LAYER
C                     ITOP - NUMBER OF TOP LEVEL OF LAYER
C           OUTPUT:   MISG - MISSING INDICATOR (1 = MISSING)
C
C         CALLING ROUTINES:
C           TU435
C
C         DESCRIPTION:
C           THIS SUBROUTINE CALCULATES THE POTENTIAL TEMPERATURE GRADIENT
C           BETWEEN TWO LAYERS.
C
      PARAMETER (NLMAX=20,NDMAX=40)
      COMMON /METCOM/DTHDZ(NLMAX),SAL(NLMAX),SEL(NLMAX),TL(NLMAX),
     1               UL(NLMAX),WDL(NLMAX),ZL(NLMAX),KLASS,LMX,MDATA,
     2               MDATB,METNAM(2),MYR,MJD,MHR,ND,NLLIM,DESC(18,NDMAX)
      DATA AMISG/-9999./
C
      IDUM = 40
      IF (ITOP .GT. NLLIM) GO TO 990
      IDUM = 50
      IF (TL(ITOP) .EQ. AMISG) GO TO 990
      IDUM = 60
      IF (TL(IBOT) .EQ. AMISG) GO TO 990
      DTHDZ(IBOT) = (TL(ITOP) - TL(IBOT))/(ZL(ITOP) - ZL(IBOT)) + 0.0098
      GO TO 999
  990 MISG = IDUM
C
  999 RETURN
      END
C
      SUBROUTINE TU515(NPT,TEMPST,UST,FDW)
C        515-CALCULATE-STACK-TIP-DOWNWASH
C
C          ARGUMENT LIST:
C            INPUT:   NPT    - SOURCE NUMBER
C                     TEMPST - AMBIENT AIR TEMPERATURE AT STACK TOP (K)
C                     UST    - WIND SPEED AT STACK TOP (M/SEC)
C            OUTPUT:  FDW    - STACK-TIP DOWNWASH CORRECTION FACTOR
C
C          CALLING ROUTINES:
C            TU435
C
C          DESCRIPTION:
C            THE STACK-TIP DOWNWASH CORRECTION FACTOR IS CALCULATED
C            ACCORDING TO METHODS SUGGESTED BY BJORKLUND AND BOWERS (1982)
C
      PARAMETER (NPTMAX=25)
      COMMON /SORCOM/D(NPTMAX),PNAME(3,NPTMAX),PSH(NPTMAX),QJ(NPTMAX),
     1               QELEV(NPTMAX),QEAST(NPTMAX),QNORD(NPTMAX),
     2               TS(NPTMAX),VS(NPTMAX),IQYR,IQJD,IQHR,NPTLIM,
     3               IMPS(NPTMAX)
C
C          CALCULATE FROUDE NUMBER.
C
      FR = VS(NPT) * VS(NPT)/9.806 * D(NPT) * (TS(NPT)-TEMPST)/TEMPST
C
      IF (FR .LT. 3.) GO TO 100
C
      IF (UST .LE. VS(NPT)/1.5) GO TO 100
C
      IF (UST .GE. VS(NPT)) GO TO 200
C
C          CALCULATE STACK-TIP DOWNWASH CORRECTION FACTOR.
C
      FDW = (3*VS(NPT) - 3*UST)/VS(NPT)
      GO TO 999
C
  100 FDW = 1.0
      GO TO 999
C
  200 FDW = 0.0
C
  999 RETURN
      END
C
      SUBROUTINE TU520(F,U,H,IB,DELH)
C        520-CALCULATE-UNSTABLE-NEUTRAL-BUOYANCY-RISE
C
C          PARAMETER LIST:
C            INPUT:   F    - BUOYANCY FLUX (M**4/S**3)
C                     U    - WIND SPEED (M/SEC)
C                     H    - PHYSICAL STACK HEIGHT (METERS)
C            OUTPUT:  IB   - EQUATION FLAG
C                     DELH - PLUME RISE (METERS)
C
C          CALLING ROUTINES:
C            TU435
C
C          DESCRIPTION:
C            THIS SUBROUTINE COMPUTES UNSTABLE-NEUTRAL BUOYANCY RISE.
C
      IB = 2
      DELH = 30. * (F/U) ** 0.6
      DUM = F/U ** 3.
      DEL5 = 24. * DUM ** 0.6 * (H + 200. * DUM) ** 0.4
      IF (DEL5 .GE. DELH) GO TO 999
      IB = 5
      DELH = DEL5
  999 RETURN
      END
C
      SUBROUTINE TU530(U,H,IB,DELH,ZT,FR)
C         530-UNSTABLE-NEUTRAL-RESIDUAL-BUOYANCY
C
C           ARGUMENT LIST:
C             INPUT:   U    - WIND SPEED (M/SEC)
C                      H    - PHYSICAL STACK HEIGHT (METERS)
C                      IB   - EQUATION FLAG
C                      DELH - PLUME RISE
C                      ZT   - HEIGHT ABOVE STACK OF UPPER LAYER (METERS)
C             OUTPUT:  FR   - RESIDUAL BUOYANCY FLUX (M**4/S**3)
C
C           CALLING ROUTINES:
C             TU435
C
C           DESCRIPTION:
C             THIS SUBROUTINE COMPUTES UNSTABLE-NEUTRAL RESIDUAL BUOYANCY.
C
      IF (IB .EQ. 5) GO TO 100
C
C           USE METHOD TWO FOR RESIDUAL BUOYANCY.
C
      FR = U * ((DELH-ZT)/30.) ** 1.66667
      GO TO 999
C
C           USE METHOD FIVE FOR RESIDUAL BUOYANCY.
C
  100 M = DELH - ZT
      FR = 0.0055 * M * U**3/(1. + H/M)**0.666667
C
  999 RETURN
      END
C
      SUBROUTINE TU540(FO,F,U,T,THZ,ZB,IS,DELH)
C         540-CALCULATE-STABLE-BUOYANCY-RISE
C
C           ARGUMENT LIST:
C             INPUT:   FO   - INITIAL BUOYANCY FLUX (M**4/S**3)
C                      F    - PREVIOUS RESIDUAL BUOYANCY
C                      U    - WIND SPEED (M/SEC)
C                      T    - AMBIENT AIR TEMPERATURE (KELVIN)
C                      THZ  - POTENTIAL TEMPERATURE GRADIENT
C                      ZB   - HEIGHT ABV STACK OF BOTTOM OF LAYER (METERS)
C             OUTPUT:  IS   - EQUATION FLAG
C                      DELH - PLUME RISE (METERS)
C
C           CALLING ROUTINES:
C             TU435
C
C           DESCRIPTION:
C             THIS SUBROUTINE CALCULATES STABLE BUOYANCY RISE.
C
C
C           CALCULATE TOP OF PLUME FOR WINDY AND CALM CONDITIONS.
C
      IS = 1
      DELHT = (1.8 * F * T/(THZ * U) + ZB ** 3.) ** 0.333333
      IF (U .GT. 1.) GO TO 999
C         USE 1 M/SEC FOR CRITERION FOR CALCULATION OF CALM RISE.
      DELHTC = (4.1 * F * T/(FO ** 0.333333 * THZ) + ZB ** 2.66667)
     1         ** 0.375
      IF (DELHT .LT. DELHTC) GO TO 999
C         SUBSTITUTE CALM RISE IF SMALLER.
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      IS = 2
      DELHT = DELHTC
C
C         CALCULATE PLUME CENTERLINE.
C
  999 DELH = 0.666667 * DELHT
      RETURN
      END
C
      SUBROUTINE TU550(FO,F,U,T,THZ,ZB,ZT,IS,FR)
C         550-CALCULATE-STABLE-RESIDUAL-BUOYANCY
C
C
C         ARGUMENT LIST:
C           INPUT:    FO   - INITIAL BUOYANCY FLUX (M**4/S**3)
C                     F    - PREVIOUS RESIDUAL BUOYANCY
C                     U    - WIND SPEED (M/SEC)
C                     T    - AMBIENT AIR TEMPERATURE (KELVIN)
C                     THZ  - POTENTIAL TEMPERATURE GRADIENT
C                     ZB   - HEIGHT ABOVE STACK OF BOTTOM OF LAYER (METERS)
C                     ZT   - HEIGHT ABOVE STACK OF TOP OF LAYER (METERS)
C                     IS   - EQUATION FLAG
C           OUTPUT:   FR   - RESIDUAL BUOYANCY (M**4/S**3)
C
C         CALLING ROUTINES:
C           TU435
C
C         DESCRIPTION:
C           THIS SUBROUTINE COMPUTES STABLE RESIDUAL BUOYANCY.
C
      IF (IS .EQ. 2) GO TO 100
C
C         CALCULATE USING WINDY FORM OF RESIDUAL BUOYANCY.
C
      FR = F - 0.56 * THZ * U/T * (ZT ** 3. - ZB ** 3.)
      GO TO 999
C
C         CALCULATE USING CALM FORM OF RESIDUAL BUOYANCY.
C
  100 FR = F - 0.24 * FO ** 0.333333 * THZ/T *
     1     (ZT ** 2.66667 - ZB ** 2.66667)
  999 RETURN
      END
C
      SUBROUTINE TU440(H,HL,DELH,HEPR,PORT,DELHPR,ZMN)
C         440-CALCULATE-PLUME-PENETRATION
C
C         ARGUMENT LIST:
C           INPUT:    H       - PHYSICAL STACK HEIGHT (METERS)
C                     HL      - MIXING HEIGHT (METERS)
C                     DELH    - PLUME RISE (METERS)
C           OUTPUT:   HEPR    - EFFECTIVE HEIGHT AFTER PLUME PENETRATION
C                                 (METERS)
C                     PORT    - PORTION OF PLUME BENEATH THE MIXING HEIGHT
C                     DELHPR  - PLUME RISE AFTER PLUME PENETRATION (METERS)
C                     ZMN     - MINIMUM DISTANCE BETWEEN THE EFFECTIVE
C                                 PLUME HEIGHT AND A BOUNDING SURFACE
C
C         CALLING ROUTINES:
C           TU330
C
C         DESCRIPTION:
C           THIS SUBROUTINE CALCULATES THE PORTION OF THE PLUME BENEATH
C           THE MIXING HEIGHT USING THE "TOP HAT" DISTRIBUTION
C           RECOMMENDED BY BRIGGS (1975).
C
      PARAMETER (NLMAX=20,NDMAX=40)
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT
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      COMMON /METCOM/DTHDZ(NLMAX),SAL(NLMAX),SEL(NLMAX),TL(NLMAX),
     1               UL(NLMAX),WDL(NLMAX),ZL(NLMAX),KLASS,LMX,MDATA,
     2               MDATB,METNAM(2),MYR,MJD,MHR,ND,NLLIM,DESC(18,NDMAX)
C
C        INITIALIZE.
C
      HE = H + DELH
      ZMN = HE
      HDELH = 0.5 * DELH
      PB = HE - HDELH
      PT = HE + HDELH
C
C        TEST FOR DAYTIME CONDITIONS.
C
      IF (KLASS .LT. 3) GO TO 50
C
C        NIGHTTIME CONDITIONS.
C
      IF (IOPM .EQ. 0) GO TO 300
      IF (PB .LT. HL) GO TO 300
      GO TO 200
C
C        DAYTIME CONDITIONS.
C
   50 IF (PT .LT. HL) GO TO 300
      IF (PB .GT. HL) GO TO 200
C
C        PART OF PLUME AVAILABLE FOR MIXING, I.E., PLUME BOTTOM LESS
C          THAN THE MIXING HEIGHT AND PLUME TOP GREATER THAN THE
C          MIXING HEIGHT.
C
      HEPR = (HL + PB)/2.
      PORT = (HL - PB)/DELH
      DELHPR = HEPR - H
      ZMN = HEPR
      IF (HL - HEPR .LT. ZMN) ZMN = HL - HEPR
      GO TO 999
C
C        NONE OF PLUME AVAILABLE FOR MIXING.
C
  200 HEPR = HE
      PORT = 0.
      DELHPR = DELH
      GO TO 999
C
C        ALL OF PLUME AVAILABLE FOR MIXING.
C
  300 HEPR = HE
      PORT = 1.
      DELHPR = DELH
      IF ((KLASS .LT. 3) .AND. (HL - HEPR .LT. ZMN)) ZMN = HL - HEPR
C
  999 RETURN
      END
C
      SUBROUTINE TU445(HEPR,UPL,WDPL,SAPL,SEPL,MISG)
C        445-CALCULATE-EMISSIONS-METEOROLOGY
C
C        ARGUMENT LIST:
C          INPUT:    HEPR - EFFECTIVE PLUME HEIGHT (METERS)
C          OUTPUT:   UPL  - WIND SPEED AT PLUME HEIGHT (M/SEC)
C                    WDPL - WIND DIRECTION AT PLUME HEIGHT (DEGREES)
C                    SAPL - SIGMA-AZIMUTH AT PLUME HEIGHT (RADIANS)
C                    SEPL - SIGMA-ELEVATION AT PLUME HEIGHT (RADIANS)
C                    MISG - MISSING CODE (IF MISG > 0, THEN MISSING)
C
C        CALLING ROUTINES:
C          TU330
C
C        DESCRIPTION:
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C
C           THIS MODULE CALCULATES WIND DIRECTION AND SPEED, SIGMA-A,
C           AND SIGMA-E AT PLUME LEVEL.  IT IS EXECUTED EACH HOUR FOR
C           EACH SOURCE.
C
      PARAMETER (NLMAX=20,NDMAX=40)
      COMMON /METCOM/DTHDZ(NLMAX),SAL(NLMAX),SEL(NLMAX),TL(NLMAX),
     1               UL(NLMAX),WDL(NLMAX),ZL(NLMAX),KLASS,LMX,MDATA,
     2               MDATB,METNAM(2),MYR,MJD,MHR,ND,NLLIM,DESC(18,NDMAX)
      DATA AMISG/-9999./
C
      IF (HEPR .LE. ZL(1)) GO TO 200
      IF (HEPR .GE. ZL(NLLIM)) GO TO 300
C
C          FIND LEVEL OF EFFECTIVE PLUME HEIGHT.
C
      DO 50 NL = 2,NLLIM
         IF (HEPR .LT. ZL(NL)) GO TO 100
   50 CONTINUE
C
C          EFFECTIVE PLUME HEIGHT IS BETWEEN FIRST AND TOP LAYER.
C
  100 IBOT = NL - 1
      ITOP = NL
      ZLYR = ZL(ITOP) - ZL(IBOT)
      FRACT = (HEPR - ZL(IBOT))/ZLYR
C
      IDUM = 150
      IF (UL(IBOT) .EQ. AMISG) GO TO 900
      IDUM = 160
      IF (UL(ITOP) .EQ. AMISG) GO TO 900
      UPL = UL(IBOT) + FRACT * (UL(ITOP) - UL(IBOT))
C
      IDUM = 170
      IF (WDL(IBOT) .EQ. AMISG) GO TO 900
      IDUM = 180
      IF (WDL(ITOP) .EQ. AMISG) GO TO 900
      DIFF = WDL(ITOP) - WDL(IBOT)
      IF (DIFF .GT. 180.) DIFF = DIFF - 360.
      IF (DIFF .LT. -180.) DIFF = DIFF + 360.
      WDPL = WDL(IBOT) + FRACT * DIFF
      IF (WDPL .GT. 360.) WDPL = WDPL - 360.
      IF (WDPL .LE. 0.) WDPL = WDPL + 360.
C
      IDUM = 190
      IF (SAL(IBOT) .EQ. AMISG) GO TO 900
      IDUM = 200
      IF (SAL(ITOP) .EQ. AMISG) GO TO 900
      SAPL = SAL(IBOT) + FRACT * (SAL(ITOP) - SAL(IBOT))
C
      IDUM = 210
      IF (SEL(IBOT) .EQ. AMISG) GO TO 900
      IDUM = 220
      IF (SEL(ITOP) .EQ. AMISG) GO TO 900
      SEPL = SEL(IBOT) + FRACT * (SEL(ITOP) - SEL(IBOT))
      GO TO 999
C
C          EFFECTIVE PLUME HEIGHT IS AT OR BELOW FIRST LAYER.
C
  200 IDUM = 120
      UPL = UL(1)
      WDPL = WDL(1)
      SAPL = SAL(1)
      SEPL = SEL(1)
      GO TO 400
C
C          EFFECTIVE PLUME HEIGHT IS AT OR ABOVE THE TOP LAYER.
C
  300 IDUM = 130
      UPL = UL(NLLIM)
      WDPL = WDL(NLLIM)
      SAPL = SAL(NLLIM)
      SEPL = SEL(NLLIM)
C
C          MAKE SURE METEOROLOGICAL DATA IS COMPLETE.
C
  400 IF ((UPL .EQ. AMISG) .OR. (WDPL .EQ. AMISG) .OR.
     1    (SAPL .EQ. AMISG) .OR. (SEPL .EQ. AMISG)) GO TO 900
      GO TO 999
C
C          SET MISSING FLAG IF METEOROLOGICAL DATA ARE INCOMPLETE.
C
  900 MISG = IDUM
C
  999 RETURN
      END
C
      SUBROUTINE TU450(X,UPL,SAPL,SEPL,DELH,SY,SZ)
C        450-CALCULATE-SIGMAS
C
C       ARGUMENT LIST:
C         INPUT:    X      - RECEPTOR TO SOURCE DISTANCE (KM)
C                   UPL    - WIND SPEED AT PLUME LEVEL (M/SEC)
C                   SAPL   - SIGMA-AZIMUTH AT PLUME HEIGHT (RADIANS)
C                   SEPL   - SIGMA-ELEVATION AT PLUME HEIGHT (RADIANS)
C                   DELH   - PLUME RISE (METERS)
C         OUTPUT:   SY     - LATERAL DISPERSION PARAMETER (METERS)
C                   SZ     - VERTICAL DISPERSION PARAMETER (METERS)
C
C       CALLING ROUTINES:
C         TU330
C
C       DESCRIPTION:
C         THIS SUBROUTINE CALCULATES SIGMA-Y AND SIGMA-Z.
C
C         MDIS IS A SELECTOR FOR DISPERSION SCHEME:
C           1 = SIMPLIFIED, 2 = MODIFIED,
C
C         AT THE PRESENT TIME ONLY THE MODIFIED DISPERSION SCHEME
C         (MDIS = 2) IS CONSIDERED.
C
      PARAMETER (NLMAX=20,NDMAX=40)
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT
      COMMON /METCOM/DTHDZ(NLMAX),SAL(NLMAX),SEL(NLMAX),TL(NLMAX),
     1               UL(NLMAX),WDL(NLMAX),ZL(NLMAX),KLASS,LMX,MDATA,
     2               MDATB,METNAM(2),MYR,MJD,MHR,ND,NLLIM,DESC(18,NDMAX)
C
      DATA MDIS/2/
C
C          CALCULATE SIGMA-Y.
C
      TX = 1000. * X
      TT = TX/UPL
      FY = 1./(1. + 0.9 * SQRT (TT/1000.))
      SY = TX * SAPL * FY
C          FOR APPLICATION TO DISTANCES BEYOND 10 KM WHERE VERTICAL WIND
C           SHEAR IS LIKELY TO CAUSE ENHANCED HORIZONTAL DISPERSION, A
C           GROWTH OF SIGMA-Y SUCH AS SY = SAPL * TX ** 0.9 MAY BE MORE
C           USEFUL (JOHN S. IRWIN, 11 FEB 82).
C
C          CALCULATE SIGMA-Z.  FIRST TEST FOR DAY- OR NIGHTTIME
C           CONDITIONS.
C
      IF (KLASS .LT. 3) GO TO 200
C          NIGHTTIME CONDITIONS.
C          SIMPLIFIED AND MODIFIED STABLE SIGMA-Z.
      FZ = 1./(1. + 0.9 * SQRT (TT/50.))
      SZ = TX * SEPL * FZ
C          NEXT STATEMENT PROBABLY UNNECESSARY.
      IF (SZ .GT. 5000.) SZ = 5000.
      GO TO 900
C          DAYTIME CONDITIONS.
  200 IF (MDIS .EQ. 2) GO TO 250
C          SIMPLIFIED UNSTABLE SIGMA-Z.
      SZ = TX * SEPL
      IF (SZ .GT. 5000.) SZ = 5000.
      GO TO 900
C          MODIFIED UNSTABLE SIGMA-Z.
  250 FZ = 1./(1. + 0.9 * SQRT (TT/500.))
      SZ = TX * SEPL * FZ
      IF (SZ .GT. 5000.) SZ = 5000.
C
C        CALCULATE BID (IF IOPB = 1).
C
  900 IF (IOPB.EQ.0) RETURN
      DUM = DELH/3.5
      DUM = DUM*DUM
      SY = SQRT(SY*SY + DUM)
      SZ = SQRT(SZ*SZ + DUM)
C
      RETURN
      END
C
      FUNCTION ZF(DA)
C
C        PARAMETER LIST:
C          DA = SIGMA Z/ZMN, WHERE ZMN IS THE MINIMUM DISTANCE BETWEEN
C                 THE EFFECTIVE PLUME HEIGHT AND A BOUNDING SURFACE
C
C        CALLING ROUTINES:
C          TU330
C
C        DESCRIPTION:
C          THIS FUNCTION CALCULATES A NORMALIZED HEIGHT OF PEAK
C          CONCENTRATION.
C
      IF (DA .LT. 0.93) GO TO 30
C          DA > 0.93
      IF (DA .LT. 1.0) GO TO 10
C          DA > 1.0
      ZF = 0.0
      GO TO 999
   10 IF (DA .LT. 0.97) GO TO 20
C          0.97 < DA < 1.0
      ZF = 13.3333 - 13.3333*DA
      GO TO 999
C          0.93 < DA < 0.97
   20 ZF = 5.25 - 5.0*DA
      GO TO 999
C          DA < 0.93
   30 IF(DA.GE.0.71) GO TO 40
C          DA < 0.71
      ZF = 1.
      GO TO 999
C          0.71 <DA < 0.93
   40 IF (DA .LT. 0.85) GO TO 50
C          0.85 < DA < 0.93
      ZF = 2.925 - 2.5*DA
      GO TO 999
C          0.71 < DA < 0.85
   50 ZF = 2.01428 - 1.42857 * DA
  999 RETURN
      END
C
      SUBROUTINE TU455(Y,Z,H,SY,SZ,HL,UST,RC)
C        455-CALCULATE-RELATIVE-CONCENTRATION
C
C        ARGUMENT LIST:
C          INPUT:   Y     - CROSSWIND SOURCE-RECEPTOR DISTANCE (KM)
C                   Z     - RECEPTOR HEIGHT (METERS)
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C                   H      - EFFECTIVE PLUME HEIGHT (METERS)             TUP28440
C                   SY     - LATERAL DISPERSION PARAMETER (METERS)       TUP28450
C                   SZ     - VERTICAL DISPERSION PARAMETER (METERS)      TUP28460
C                   HL     - MIXING DEPTH (METERS)                       TUP28470
C                   UST    - WIND SPEED AT STACK TOP (M/SEC)             TUP28480
C          OUTPUT:  RC     - RELATIVE CONCENTRATION (SEC/M**3)           TUP28490
C                                                                        TUP28500
C        CALLING ROUTINES:                                               TUP28510
C          TU330                                                         TUP28520
C                                                                        TUP28530
C        DESCRIPTION:                                                    TUP28540
C          TU460 DETERMINES RELATIVE CONCENTRATIONS, CHI/Q, FROM POINT   TUP28550
C          SOURCES.  THE FOLLOWING EQUATION IS SOLVED --                 TUP28560
C                                                                        TUP28570
C        RC = (1/(2*PI*UST*SIGMA Y*SIGMA Z))*(EXP(-0.5*(Y/SIGMA Y)**2))  TUP28580
C           (EXP(-0.5*((Z-H)/SIGMA Z)**2) + EXP(-0.5*((Z+H)/SIGMA Z)**2)TUP28590
C                                                                        TUP28600
C          PLUS THE SUM OF THE FOLLOWING 4 TERMS K TIMES (N=1,K) --      TUP28610
C          FOR NEUTRAL OR UNSTABLE CASES:                                TUP28620
C              TERM 1- EXP(-0.5*((Z-H-2NL)/SIGMA Z)**2)                  TUP28630
C              TERM 2- EXP(-0.5*((Z+H-2NL)/SIGMA Z)**2)                  TUP28640
C              TERM 3- EXP(-0.5*((Z-H+2NL)/SIGMA Z)**2)                  TUP28650
C              TERM 4- EXP(-0.5*((Z+H+2NL)/SIGMA Z)**2)                  TUP28660
C                                                                        TUP28670
C          NOTE THAT MIXING HEIGHT -- THE TOP OF THE NEUTRAL OR UNSTABLETUP28680
C          LAYER -- HAS A VALUE ONLY FOR STABILITIES 1-3, THAT IS,       TUP28690
C          MIXING HEIGHT, THE HEIGHT OF THE NEUTRAL OR UNSTABLE LAYER,   TUP28700
C          DOES NOT EXIST FOR STABLE LAYERS AT THE GROUND SURFACE --     TUP28710
C          STABILITY 4.  THE ABOVE EQUATION IS SIMILAR TO EQ. 5.8 (P 36)TUP28720
C          IN WORKBOOK OF ATMOSPHERIC DISPERSION ESTIMATES WITH THE      TUP28730
C          ADDITION OF THE EXPONENTIAL INVOLVING Y.                      TUP28740
C                                                                        TUP28750
C          HAVE CHECKED TO SEE IF PLUME ABOVE MIXING HEIGHT.             TUP28760
C          HAVE CHECKED TO SEE IF RECEPTOR IS ABOVE MIXING HEIGHT.       TUP28770
C          HAVE CHECKED TO SEE IF X IS LESS THAN 1 METER.                TUP28780
C                                                                        TUP28790
      PARAMETER (NLMAX=20,NDMAX=40)                                      TUP28800
      COMMON /METCOM/DTHDZ(NLMAX),SAL(NLMAX),SEL(NLMAX),TL(NLMAX),       TUP28810
     1               UL(NLMAX),WDL(NLMAX),ZL(NLMAX),KLASS,LMX,MDATA,     TUP28820
     2               MDATB,METNAM(2),MYR,MJD,MHR,ND,NLLIM,DESC(18,NDMAX)TUP28830
C                                                                        TUP28840
      C1 = 1.                                                            TUP28850
      IF (Y .EQ. 0.0) GO TO 10                                           TUP28860
      YD = 1000. * Y                                                     TUP28870
C         YD IS CROSSWIND DISTANCE IN METERS.                            TUP28880
      DUM = YD/SY                                                        TUP28890
      TEMP = 0.5 * DUM * DUM                                             TUP28900
      IF (TEMP .GE. 50.) GO TO 50                                        TUP28910
      C1 = EXP(TEMP)                                                     TUP28920
   10 IF (KLASS .LT. 3) GO TO 300                                        TUP28930
      C2 = 2. * SZ * SZ                                                  TUP28940
C         IF NIGHTTIME CONDITION,                                        TUP28950
C          USE EQUATION 3.2 IF Z = 0, OR EQ 3.1 FOR NON-ZERO Z.          TUP28960
C          (EQUATION NUMBERS REFER TO WORKBOOK OF ATMOSPHERIC DISPERSIONTUP28970
C          ESTIMATES.)                                                   TUP28980
      IF (Z) 50,100,200                                                  TUP28990
C         AN ERRONEOUS NEGATIVE Z WILL RESULT IN ZERO CONCENTRATIONS     TUP29000
   50 RC = 0.                                                            TUP29010
      GO TO 999                                                          TUP29020
C                                                                        TUP29030
C         STABLE OR UNLIMITED MIXING, Z IS ZERO.                         TUP29040
C                                                                        TUP29050
  100 C3 =H * H/C2                                                       TUP29060
      IF (C3 .GE. 50.) GO TO 50                                          TUP29070
      A2 = 1./EXP(C3)                                                    TUP29080
C         WADE EQUATION 3.2.                                             TUP29090
      RC=A2/(3.14159*UST*SY*SZ*C1)                                       TUP29100
      GO TO 999                                                          TUP29110
C                                                                        TUP29120
C         STABLE OR UNLIMITED MIXING, Z IS NON-ZERO.                     TUP29130
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C                                                                       TUP29140
  200 A2 = 0.                                                           TUP29150
      A3 = 0.                                                           TUP29160
      CA = Z - H                                                        TUP29170
      CB = Z + H                                                        TUP29180
      C3 = CA * CA/C2                                                   TUP29190
      C4 = CB * CB/C2                                                   TUP29200
      IF (C3 .GE. 50.) GO TO 210                                        TUP29210
      A2 = 1./EXP(C3)                                                   TUP29220
  210 IF (C4 .GE. 50.) GO TO 220                                        TUP29230
      A3 = 1./EXP(C4)                                                   TUP29240
C         WADE EQUATION 3.1.                                            TUP29250
  220 RC = (A2 + A3)/(6.28318 * UST * SY * SZ * C1)                     TUP29260
      GO TO 999                                                         TUP29270
C                                                                       TUP29280
C         UNSTABLE, ASSURED OF UNIFORM MIXING.                          TUP29290
C                                                                       TUP29300
C         IF SIGMA-Z IS GREATER THAN 1.6 TIMES THE MIXING HEIGHT,       TUP29310
C          THE DISTRIBUTION BELOW THE MIXING HEIGHT IS UNIFORM WITH     TUP29320
C          HEIGHT REGARDLESS OF SOURCE HEIGHT OR RECEPTOR HEIGHT BECAUSETUP29330
C          OF REPEATED EDDY REFLECTIONS FROM THE GROUND AND THE MIXING  TUP29340
C          HEIGHT.                                                      TUP29350
  300 IF (SZ/HL .LE. 1.6) GO TO 310                                     TUP29360
C         WADE EQUATION 3.5.                                            TUP29370
      RC = 1./(2.5066 * UST * SY * HL * C1)                             TUP29380
      GO TO 999                                                         TUP29390
C         INITIAL VALUE OF AN SET EQUAL TO ZERO.                        TUP29400
C          AN - THE NUMBER OF TIMES THE SUMMATION TERM IS EVALUATED     TUP29410
C                AND ADDED IN.                                          TUP29420
  310 AN = 0.                                                           TUP29430
      IF (Z) 50,500,400                                                 TUP29440
C                                                                       TUP29450
C         UNSTABLE, CALCULATE MULTIPLE EDDY REFLECTIONS, Z IS NON-ZERO. TUP29460
C                                                                       TUP29470
C         SEVERAL INTERMEDIATE VARIABLES ARE USED TO AVOID REPEATING    TUP29480
C          CALCULATIONS.  CHECKS ARE MADE TO BE SURE THAT THE ARGUMENT  TUP29490
C          OF THE EXPONENTIAL FUNCTION IS NEVER GREATER THAN 50 (OR LESSTUP29500
C          THAN -50).  CALCULATE MULTIPLE EDDY REFLECTIONS FOR RECEPTOR TUP29510
C          HEIGHT Z.                                                    TUP29520
  400 A1 = 1./(6.28318 * UST * SY * SZ * C1)                            TUP29530
      C2 = 2. * SZ * SZ                                                 TUP29540
      A2 = 0.                                                           TUP29550
      A3 = 0.                                                           TUP29560
      CA = Z - H                                                        TUP29570
      CB = Z + H                                                        TUP29580
      C3 = CA * CA/C2                                                   TUP29590
      C4 = CB * CB/C2                                                   TUP29600
      IF (C3 .GE. 50.) GO TO 410                                        TUP29610
      A2 = 1./EXP(C3)                                                   TUP29620
  410 IF (C4 .GE. 50.) GO TO 420                                        TUP29630
      A3 = 1./EXP(C4)                                                   TUP29640
  420 SUM = 0.                                                          TUP29650
      THL = 2. * HL                                                     TUP29660
  430 AN = AN + 1.                                                      TUP29670
      A4 = 0.                                                           TUP29680
      A5 = 0.                                                           TUP29690
      A6 = 0.                                                           TUP29700
      A7 = 0.                                                           TUP29710
      C5 = AN * THL                                                     TUP29720
      CC = CA - C5                                                      TUP29730
      CD = CB - C5                                                      TUP29740
      CE = CA + C5                                                      TUP29750
      CF = CB + C5                                                      TUP29760
      C6 = CC * CC/C2                                                   TUP29770
      C7 = CD * CD/C2                                                   TUP29780
      C8 = CE * CE/C2                                                   TUP29790
      C9 = CF * CF/C2                                                   TUP29800
      IF (C6 .GE. 50.) GO TO 440                                        TUP29810
      A4 = 1./EXP(C6)                                                   TUP29820
  440 IF (C7 .GE. 50.) GO TO 450                                        TUP29830
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      A5 = 1./EXP(C7)
  450 IF (C8 .GE. 50.) GO TO 460
      A6 = 1./EXP(C8)
  460 IF (C9 .GE. 50.) GO TO 470
      A7 = 1./EXP(C9)
  470 T = A4 + A5 + A6 + A7
      SUM = SUM + T
      IF (T .GE. 0.01) GO TO 430
      RC = A1 * (A2 + A3 + SUM)
      GO TO 999
C
C
C         UNSTABLE, CALCULATE MULTIPLE EDDY REFLECTIONS, Z IS ZERO.
C          CALCULATE MULTIPLE EDDY REFLECTIONS FOR GROUND LEVEL RECEPTOR
C
  500 A1 = 1./(6.28318 * UST * SY * SZ * C1)
      A2 = 0.
      C2 = 2. * SZ * SZ
      C3 = H * H/C2
      IF (C3 .GE. 50.) GO TO 510
      A2 = 2./EXP(C3)
  510 SUM = 0.
      THL = 2. * HL
  520 AN = AN + 1.
      A4 = 0.
      A6 = 0.
      C5 = AN * THL
      CC = H - C5
      CE = H + C5
      C6 = CC * CC/C2
      C8 = CE * CE/C2
      IF (C6 .GE. 50.) GO TO 530
      A4 = 2./EXP(C6)
  530 IF (C8 .GE. 50.) GO TO 540
      A6 = 2./EXP(C8)
  540 T = A4 + A6
      SUM = SUM + T
      IF (T .GE. 0.01) GO TO 520
      RC = A1 * (A2 + SUM)
C
  999 RETURN
      END
C
      SUBROUTINE TU335(IYR,IDY,LH,HMAX,IYRMAX,IDYMAX,LHMAX,MAXREC)
C        335-UPDATE-MAXIMUM-CONCENTRATION
C
C        ARGUMENT LIST:
C          INPUT:    IYR    - YEAR TO SIMULATE
C                    IDY    - DAY TO SIMULATE
C                    LH     - HOUR TO SIMULATE
C          I/O:      HMAX   - MAXIMUM HOURLY CONCENTRATION (G/M**3)
C          OUTPUT:   IYRMAX - YEAR OF MAXIMUM
C                    IDYMAX - DAY OF MAXIMUM
C                    LHMAX  - HOUR OF MAXIMUM
C                    MAXREC - RECEPTOR NUMBER OF MAXIMUM
C
C        CALLING ROUTINES:
C          TU220
C
C        DESCRIPTION:
C          THIS MODULE IS CALLED BY SUBROUTINE TU220 TO UPDATE THE
C          MAXIMUM HOURLY CONCENTRATION.
C
      PARAMETER (NPTMAX=25,NREMAX=180)
      COMMON /RECCOM/ELR(NREMAX),PARTC(NREMAX,NPTMAX),PHCHI(NREMAX),
     1               RNAME(2,NREMAX),RREC(NREMAX),SREC(NREMAX),
     2               STAR(2,NREMAX),ZR(NREMAX),NRELIM
C
      DO 100 NRE = 1,NRELIM
         IF (PHCHI(NRE) .LE. HMAX) GO TO 100
         HMAX   = PHCHI(NRE)
         IYRMAX = IYR
         IDYMAX = IDY
         LHMAX  = LH
         MAXREC = NRE
  100 CONTINUE
      RETURN
      END
C
      SUBROUTINE TU340(IYR,IDY,LH,HSAV,DSAV)
C        340-OUTPUT-HOURLY-RESULTS
C
C        ARGUMENT LIST:
C          INPUT:   IYR    - YEAR TO SIMULATE
C                   IDY    - JULIAN DAY TO SIMULATE
C                   LH     - HOUR TO SIMULATE
C                   HSAV   - PLUME HEIGHTS FOR THIS HOUR (METERS)
C                   DSAV   - DISTANCE TO FINAL RISE FOR THIS HOUR
C
C        CALLING ROUTINES:
C          TU220
C
C        DESCRIPTION:
C          THIS SUBROUTINE OUTPUTS TOTAL HOURLY CONCENTRATIONS IN
C          MICROGRAMS PER CUBIC METER BY USING A "6P" SCALE FACTOR IN
C          FORMAT STATEMENT 1060.
C
      PARAMETER (NLMAX=20,NPTMAX=25,NREMAX=180,NDMAX=40)
      DIMENSION IRANK(NREMAX),HSAV(NPTMAX),DSAV(NPTMAX),
     1          CSAV(NREMAX)
      DIMENSION ALP(NLMAX)
      COMMON /RUNCOM/CELM,CONTWO,CTER,HAFL,TLOS,CONTER(4),IYRS,IDYS,
     1               IHRS,IHLIM,IOPT,IOPB,IOPD,IOPG,IOPM,IOPQ,IOPR,
     2               IOPWPC,NPOL,LINE1(20),LINE2(20),LINE3(20),NPRNT
      COMMON /METCOM/DTHDZ(NLMAX),SAL(NLMAX),SEL(NLMAX),TL(NLMAX),
     1               UL(NLMAX),WDL(NLMAX),ZL(NLMAX),KLASS,LMX,MDATA,
     2               MDATB,METNAM(2),MYR,MJD,MHR,ND,NLLIM,DESC(18,NDMAX)
      COMMON /SORCOM/D(NPTMAX),PNAME(3,NPTMAX),PSH(NPTMAX),QJ(NPTMAX),
     1               QELEV(NPTMAX),QEAST(NPTMAX),QNORD(NPTMAX),
     2               TS(NPTMAX),VS(NPTMAX),IQYR,IQJD,IQHR,NPTLIM,
     3               IMPS(NPTMAX)
      COMMON /RECCOM/ELR(NREMAX),PARTC(NREMAX,NPTMAX),PHCHI(NREMAX),
     1               RNAME(2,NREMAX),RREC(NREMAX),SREC(NREMAX),
     2               STAR(2,NREMAX),ZR(NREMAX),NRELIM
      COMMON /INOUT/ IN,IO
      DATA BLNK /' '/, ASTR /'*'/
C
C        PRINT TITLE.
C
      WRITE(IO,1000) LINE1,LINE2,LINE3
C
C       LIST MET DATA.
C
      LIM = NLLIM - 1
      DO 200 L = 1,LIM
      LT = L + 1
      DTHDZ(L) = (TL(LT) - TL(L))/(ZL(LT) - ZL(L)) + 0.0098
  200 IF (TL(LT).EQ.-9999..OR.TL(L).EQ.-9999.) DTHDZ(L) = -9999.9999
      DO 250 L = 1,NLLIM
      ALP(L) = BLNK
      IF (L.EQ.LMX) ALP(L) = ASTR
  250 CONTINUE
      WRITE (6,1090) MYR,MJD,MHR,LMX,KLASS
      WRITE (6,1100) NLLIM,ZL(NLLIM),ALP(NLLIM),SAL(NLLIM),SEL(NLLIM),
     1WDL(NLLIM), UL(NLLIM),TL(NLLIM)
      DO 300 L = 1,LIM
      LT = NLLIM - L
  300 WRITE (6,1100) LT,ZL(LT),ALP(LT),SAL(LT),SEL(LT),WDL(LT),UL(LT),
     1TL(LT),DTHDZ(LT)
C
C        PRINT FINAL PLUME HEIGHT AND DISTANCE TO FINAL RISE.
```

```
C
      WRITE(IO,1010) (I, I = 1,10)                                      TUP31220
      WRITE(IO,1020) (HSAV(NPT), NPT = 1,NPTLIM)                        TUP31230
      WRITE(IO,1030) (DSAV(NPT), NPT = 1,NPTLIM)                        TUP31240
C                                                                       TUP31250
C         PRINT HOURLY CONCENTRATION TABLE.                             TUP31260
C                                                                       TUP31270
      WRITE(IO,1040) NPOL,IYR,IDY,LH                                    TUP31280
      WRITE(IO,1050)                                                    TUP31290
C         CALCULATE GRAND TOTALS AND RANK CONCENTRATIONS.               TUP31300
      DO 30 NRE = 1,NRELIM                                              TUP31310
         CSAV(NRE) = PHCHI(NRE)                                         TUP31320
   30 CONTINUE                                                          TUP31330
C         DETERMINE RANKING ACCORDING TO CONCENTRATION.                 TUP31340
      DO 50 I = 1,NRELIM                                                TUP31350
         CMAX = -1.0                                                    TUP31360
         DO 40 K = 1,NRELIM                                             TUP31370
            IF (CSAV(K) .LE. CMAX) GO TO 40                             TUP31380
            CMAX = CSAV(K)                                              TUP31390
            LMAX=K                                                      TUP31400
   40    CONTINUE                                                       TUP31410
         IRANK(LMAX) = I                                                TUP31420
         CSAV(LMAX) = -1.0                                              TUP31430
   50 CONTINUE                                                          TUP31440
      DO 60 NRE = 1,NRELIM                                              TUP31450
         WRITE(IO,1060) NRE,(RNAME(J,NRE), J = 1,2),RREC(NRE),SREC(NRE),TUP31460
     1                  ELR(NRE),STAR(1,NRE),STAR(2,NRE),ZR(NRE),       TUP31470
     2                  PHCHI(NRE),IRANK(NRE)                           TUP31480
   60 CONTINUE                                                          TUP31490
C                                                                       TUP31500
      RETURN                                                            TUP31510
C                                                                       TUP31520
C         FORMAT STATEMENTS.                                            TUP31530
C                                                                       TUP31540
 1000 FORMAT(1H1,'TITLE:  ',20A4,2(/,9X,20A4)/)                         TUP31550
 1090 FORMAT (' MET DATA FOR YEAR:',I3,'  JUL DAY:',I4,'  HOUR:',       TUP31560
     1 I3,'  LMX =',I2,'  KLASS =',I2/' LVL      HT    MIX       ',     TUP31570
     2 'SA          SE          WD          U          T          DTHDZ')TUP31580
 1100 FORMAT (I3,F10.1,2X,A1,2X,2F10.4,F10.1,2F10.2,F10.4)              TUP31590
 1010 FORMAT(1H0,12X,10I11)                                             TUP31600
 1020 FORMAT(' FINAL HT (M)    ',10(F8.1,3X))                           TUP31610
 1030 FORMAT(' DIST FIN HT (KM)',10(F10.3,1X))                          TUP31620
 1040 FORMAT(1H0,30X,'* * * ',A4,' CONCENTRATION TABLE FOR HOUR ',I2,   TUP31630
     1              '-',I3,'-',I2,' * * *')                             TUP31640
 1050 FORMAT(1H0,'RECEPTOR    IDENTIFICATION          ------------COORDI',TUP31650
     1          'NATES------------          HEIGHT ABOVE',/,            TUP31660
     2        1X,45X,'(USER UNITS)',16X,'LOCAL GRD-LVL      ',          TUP31670
     3          'CONCENTRATION       RANK',/,                           TUP31680
     4        1X,38X,'EAST          NORTH          ELEV          (M)',9X, TUP31690
     5          '(MICROGRAMS/M**3)')                                    TUP31700
 1060 FORMAT(1X,I5,10X,2A4,6X,3F13.2,1X,2A1,1X,F9.2,8X,6PF13.2,7X,I5)   TUP31710
      END                                                               TUP31720
C                                                                       TUP31730
      SUBROUTINE CHRON(IYR,IJD,IHR,IYDH)                                TUP31740
C        CHRON-CONVERT-DATE                                             TUP31750
C                                                                       TUP31760
C        ARGUMENT LIST:                                                 TUP31770
C           INPUT:   IYR  - YEAR (2 DIGITS)                             TUP31780
C                    IJD  - JULIAN DAY (3 DIGITS)                       TUP31790
C                    IHR  - HOUR (2 DIGITS)                             TUP31800
C           OUTPUT:  IYDH - DATE CONVERTED TO HOUR                      TUP31810
C                                                                       TUP31820
C        CALLING ROUTINES:                                              TUP31830
C           TU220, TU320, TU325                                         TUP31840
C                                                                       TUP31850
C        DESCRIPTION:                                                   TUP31860
C           THIS SUBROUTINE CONVERTS DATES BETWEEN 1960 AND 1999 TO A   TUP31870
C           COMMON SEQUENTIAL HOUR.  THE ZERO POINT IS 1959, 365, 24,   TUP31880
C           I.E., HOUR 1 IS THE FIRST HOUR OF 1960.                     TUP31890
C                                                                       TUP31900
```

```
      DIMENSION ICUM(41),NDAY(40)
      COMMON /INOUT/ IN,IO
      DATA ICUM/     0,  8784, 17544, 26304, 35064, 43848, 52608,
     1           61368, 70128, 78912, 87672, 96432,105192,113976,
     2          122736,131496,140256,149040,157800,166560,175320,
     3          184104,192864,201624,210384,219168,227928,236688,
     4          245448,254232,262992,271752,280512,289296,298056,
     5          306816,315576,324360,333120,341880,350640/
      DATA NDAY/366,365,365,365,
     1          366,365,365,365,
     2          366,365,365,365,
     3          366,365,365,365,
     4          366,365,365,365,
     5          366,365,365,365,
     6          366,365,365,365,
     7          366,365,365,365,
     8          366,365,365,365,
     9          366,365,365,365/
      DATA IZPT/59/
C
C          SCREEN INPUT.
C
      IF ((IYR .GT. 59) .AND. (IYR .LT. 100)) GO TO 100
      WRITE(IO,1000) IYR
      GO TO 990
C
  100 IF ((IJD .GT. 0) .AND. (IJD .LT. 367)) GO TO 200
      WRITE(IO,1010) IJD
      GO TO 990
C
  200 IF ((IHR .GT. 0) .AND. (IHR .LT. 25)) GO TO 300
      WRITE(IO,1020) IHR
      GO TO 990
C
  300 NYR = IYR - IZPT
      IF (IJD .LE. NDAY(NYR)) GO TO 400
      WRITE(IO,1030) IJD,IYR
      GO TO 990
C
C          CONVERT YEAR/JULIAN DAY/HOUR TO COMMON SEQUENTIAL HOUR.
C
  400 IYDH = ICUM(NYR) + (IJD - 1) * 24 + IHR
      GO TO 999
C
C          ERROR PROCESSING.
C
  990 IYDH = -999999
C
  999 RETURN
C
C          FORMAT STATEMENTS.
C
 1000 FORMAT('0*** YEAR INPUT (',I4,') IS NOT WITHIN RANGE OF 60-99.')
 1010 FORMAT('0*** JULIAN DAY INPUT (',I4,') IS NOT WITHIN RANGE OF ',
     1       '1-366.')
 1020 FORMAT('0*** HOUR INPUT (',I4,') IS NOT WITHIN RANGE OF 1-24.')
 1030 FORMAT('0*** JULIAN DAY INPUT (',I4,') CANNOT BE USED FOR YEAR ',
     2       I2,'; THIS IS NOT A LEAP YEAR.')
      END
C
      SUBROUTINE ICHRON(IYDH,IYR,IJD,IHR)
C        ICHRON-CONVERT-DATE
C
C        ARGUMENT LIST:
C          INPUT:   IYDH - COMMON SEQUENTIAL HOUR
C          OUTPUT:  IYR  - YEAR (2 DIGITS)
C                   IJD  - JULIAN DAY (3 DIGITS)
C                   IHR  - HOUR (2 DIGITS)
C
C        CALLING ROUTINES:
```

```
C          TU220
C
C       DESCRIPTION:
C          THIS SUBROUTINE CONVERTS A COMMON SEQUENTIAL HOUR TO A DATE
C          BETWEEN 1960 AND 1999.  THE ZERO POINT IS 1959, 365, 24,
C          I.E., HOUR 1 IS THE FIRST HOUR OF 1960.
C
      DIMENSION ICUM(41),NDAY(40)
      COMMON /INOUT/ IN,IO
      DATA ICUM/      0,  8784, 17544, 26304, 35064, 43848, 52608,
     1           61368, 70128, 78912, 87672, 96432,105192,113976,
     2          122736,131496,140256,149040,157800,166560,175320,
     3          184104,192864,201624,210384,219168,227928,236688,
     4          245448,254232,262992,271752,280512,289296,298056,
     5          306816,315576,324360,333120,341880,350640/
      DATA NDAY/366,365,365,365,
     1          366,365,365,365,
     2          366,365,365,365,
     3          366,365,365,365,
     4          366,365,365,365,
     5          366,365,365,365,
     6          366,365,365,365,
     7          366,365,365,365,
     8          366,365,365,365,
     9          366,365,365,365/
      DATA IZPT/59/
C
C       SCREEN INPUT.
C
      IF ((IYDH .GT. ICUM(1)) .AND. (IYDH .LE. ICUM(41))) GO TO 100
      WRITE(IO,1000) IYDH
      IYR = -999999
      IJD = -999999
      IHR = -999999
      GO TO 999
C
C       CONVERT COMMON SEQUENTIAL HOUR TO YEAR/JULIAN DAY/HOUR.
C
  100 NYR = IYDH/8760 + 1
C
  200 DIFF = IYDH - ICUM(NYR)
      IF (DIFF.GE. 0.) GO TO 300
      NYR = NYR - 1
      GO TO 200
C
  300 IF (DIFF .NE. 0.) GO TO 400
C       IS THE LAST HOUR OF THE PREVIOUS YEAR.
      NYR = NYR - 1
      IYR = NYR + IZPT
      IJD = NDAY(NYR)
      IHR = 24
      GO TO 999
C
  400 IYR = NYR + IZPT
      IHTY = DIFF
      IJD = IHTY/24
      IHR = IHTY - IJD * 24
      IF (IHR.EQ.0) THEN
      IHR = 24
      ELSE
      IJD = IJD + 1
      END IF
C
  999 RETURN
C
C       FORMAT STATEMENTS.
C
 1000 FORMAT('0*** COMMON SEQUENTIAL HOUR INPUT (',I7,') IS NOT ',
     1       'WITHIN THE REQUIRED RANGE FOR CONVERSION TO DATES ',
     2       'BETWEEN YEARS 60 AND 99.')
      END
```

APPENDIX B

LISTING OF FORTRAN SOURCE CODE FOR METVER

METVER generates the meteorological data file which may be used to verify TUPOS. The source code listing is given on the following pages.

```
C
C                   METVER (VERSION 85093)
C                   A UTILITY PROCESSOR FOR TUPOS IN
C                   SECTION 2. NON-GUIDELINE MODELS,
C                   IN UNAMAP (VERSION 6) JUL 86.
C                   SOURCE: UNAMAP FILE ON EPA'S UNIVAC 1110, RTP, NC.
C
C        THIS PROGRAM GENERATES THE UNFORMATTED METEOROLOGICAL DATA
C         FILE TO BE USED IN THE VERIFICATION RUN OF THE TUPOS USER'S
C         GUIDE.
C
      DIMENSION METNAM(2),DESC(18,5),MYR(13),MJD(13),MHR(13),NLLIM(13),
     1          LMX(13),KLASS(13),ZL(6,13),TL(6,13),WDL(6,13),UL(6,13),
     2          SAL(6,13),SEL(6,13)
      DATA METNAM/'SET6','    '/
      DATA MDATA,MDATB,ND/840210,105523,5/
      DATA DESC/'SYNT','HETI','C DA','TA S','ET W','ITH ','HOUR','S MI',
     1          'SSIN','G AN','D DA','TA M','ISSI','NG. ','4*  ',
     2          'DATA',' AVA','ILAB','LE F','OR H','OURS',' 15,','16,1',
     3          '7,21',',22,','23,0','2,03',',04,','07,0','8,09',', AN',
     4          'D 14','.   ',
     5          'NO D','ATA ','FOR ','HOUR','S 18',',19,','20,2','4,01',
     6          ',05,','06,1','0,11',',12,',' AND',' 13.','4*  ',
     7          'HOUR',' 21 ','HAS ','ONLY',' 3 L','EVEL','S.  ','SOME',
     8          ' TEM','PERA','TURE','S AR','E MI','SSIN','G FO','R HO',
     9          'UR 0','2.  ',
     A          'VARI','ATIO','N AP','PROX','IMAT','ES A',' CLE','AR D',
     B          'AY A','ND N','IGHT','.   ','6*  '/
      DATA MYR  / 83, 83, 83, 83, 83, 83, 84, 84, 84, 84, 84, 84, 84/
      DATA MJD  /365,365,365,365,365,365,001,001,001,001,001,001,001/
      DATA MHR  / 15, 16, 17, 21, 22, 23, 02, 03, 04, 07, 08, 09, 14/
      DATA NLLIM/  6,  6,  6,  6,  6,  6,  6,  6,  6,  6,  6,  6,  6/
      DATA LMX  /  4,  4,  4,  2,  4,  4,  4,  4,  4,  4,  4,  4,  6/
      DATA KLASS/  1,  1,  1,  4,  4,  4,  4,  4,  4,  3,  3,  2,  1/
      DATA ZL /     50.,    100.,    200.,   1500.,   1600.,   1800.,
     1              50.,    100.,    200.,   1500.,   1600.,   1800.,
     2              50.,    100.,    200.,   1500.,   1600.,   1800.,
     3              50.,    100.,    200.,  -9999.,  -9999.,  -9999.,
     4              50.,    100.,    200.,   1500.,   1600.,   1800.,
     5              50.,    100.,    200.,   1500.,   1600.,   1800.,
     6              50.,    100.,    200.,   1500.,   1600.,   1800.,
     7              50.,    100.,    200.,   1500.,   1600.,   1800.,
     8              50.,    100.,    200.,   1500.,   1600.,   1800.,
     9              50.,    100.,    200.,   1600.,   1800.,   2000.,
     A              50.,    100.,    200.,   1600.,   1800.,   2000.,
     B              50.,    100.,    200.,   1600.,   1800.,   2000.,
     C              50.,    100.,    200.,   1600.,   1800.,   2000./
      DATA TL /  293.5,   293.0,   292.0,   285.5,   287.5,   286.5,
     1           293.3,   293.0,   293.0,   285.5,   287.5,   286.5,
     2           293.1,   293.0,   292.5,   285.5,   287.5,   286.5,
     3           292.0,   292.0,   291.8,  -9999.,  -9999.,  -9999.,
     4           291.5,   291.7,   291.8,   285.5,   287.5,   286.5,
     5           291.0,   291.3,   291.7,   285.5,   287.5,   286.5,
     6           289.8,   290.0,  -9999.,  -9999.,   287.5,   286.5,
     7           289.5,   289.7,   291.5,   285.5,   287.5,   286.5,
     8           289.2,   289.6,   291.5,   285.5,   287.5,   286.5,
     9           288.7,   289.5,   291.5,   286.5,   290.5,   289.5,
     A           289.0,   289.6,   291.5,   285.5,   289.5,   289.5,
     B           289.9,   290.0,   291.5,   284.5,   288.5,   287.5,
     C           294.7,   294.1,   293.0,   279.0,   283.0,   282.0/
      DATA WDL/   263.,    265.,    268.,    270.,    272.,    273.,
     1            264.,    266.,    268.,    269.,    271.,    273.,
     2            265.,    267.,    269.,    271.,    272.,    273.,
     3            258.,    262.,    265.,  -9999.,  -9999.,  -9999.,
     4            256.,    261.,    263.,    270.,    272.,    275.,
     5            254.,    260.,    263.,    271.,    272.,    273.,
     6            256.,    258.,    263.,    272.,    271.,    270.,
     7            255.,    258.,    264.,    271.,    271.,    271.,
     8            254.,    257.,    262.,    269.,    270.,    272.,
     9            252.,    258.,    265.,    271.,    273.,    276.,
     A            253.,    260.,    266.,    270.,    272.,    274.,
     B           255.,    262.,    267.,    271.,    272.,    272.,
     C           264.,    266.,    268.,    269.,    271.,    270./
      DATA UL /  2.30,    2.40,    2.50,    4.50,    7.00,    8.00,
     1           2.26,    2.40,    2.50,    4.50,    7.00,    8.00,
     2           2.23,    2.40,    2.50,    4.50,    7.00,    8.00,
     3           2.00,    2.20,    2.50,-9999.,-9999.,-9999.,
     4           1.90,    2.13,    2.50,    4.50,    7.00,    8.00,
     5           1.80,    2.06,    2.50,    4.50,    7.00,    8.00,
     6           1.50,    1.86,    2.50,    4.50,    7.00,    8.00,
     7           1.40,    1.80,    2.50,    4.50,    7.00,    8.00,
     8           1.32,    1.76,    2.50,    4.50,    7.00,    8.00,
     9           1.40,    1.80,    2.50,    7.00,    8.00,    9.00,
     A           1.60,    1.90,    2.50,    7.00,    8.00,    9.00,
     B           1.90,    2.10,    2.50,    7.00,    8.00,    9.00,
     C           2.30,    2.40,    2.50,    5.00,    8.00,    9.00/
      DATA SAL/ 0.219,   0.198,   0.178,   0.132,   0.130,   0.128,
     1          0.209,   0.189,   0.164,   0.138,   0.124,   0.107,
     2          0.197,   0.174,   0.158,   0.142,   0.118,   0.094,
     3          0.132,   0.111,   0.092,-9999.,-9999.,-9999.,
     4          0.119,   0.099,   0.085,   0.055,   0.048,   0.046,
     5          0.105,   0.085,   0.070,   0.037,   0.036,   0.035,
     6          0.079,   0.067,   0.056,   0.049,   0.038,   0.027,
     7          0.075,   0.066,   0.050,   0.041,   0.033,   0.024,
     8          0.069,   0.058,   0.045,   0.032,   0.027,   0.021,
     9          0.048,   0.039,   0.032,   0.017,   0.016,   0.016,
     A          0.052,   0.043,   0.035,   0.026,   0.024,   0.022,
     B          0.071,   0.061,   0.050,   0.040,   0.034,   0.030,
     C          0.205,   0.194,   0.175,   0.132,   0.130,   0.127/
      DATA SEL/ 0.134,   0.152,   0.172,   0.248,   0.251,   0.256,
     1          0.123,   0.134,   0.142,   0.161,   0.176,   0.183,
     2          0.112,   0.111,   0.110,   0.108,   0.107,   0.106,
     3          0.091,   0.078,   0.064,-9999.,-9999.,-9999.,
     4          0.082,   0.069,   0.058,   0.047,   0.041,   0.041,
     5          0.070,   0.061,   0.053,   0.045,   0.038,   0.032,
     6          0.052,   0.043,   0.038,   0.036,   0.031,   0.026,
     7          0.046,   0.039,   0.035,   0.031,   0.027,   0.024,
     8          0.041,   0.036,   0.031,   0.026,   0.022,   0.020,
     9          0.032,   0.028,   0.024,   0.016,   0.015,   0.015,
     A          0.041,   0.038,   0.032,   0.023,   0.018,   0.017,
     B          0.056,   0.048,   0.041,   0.034,   0.021,   0.019,
     C          0.129,   0.149,   0.168,   0.228,   0.234,   0.241/
      WRITE (6,1234)
 1234 FORMAT ('1',21X,'METVER (VERSION 85093)'/
     1 22X,'A UTILITY PROCESSOR FOR TUPOS IN'/
     2 22X,'SECTION 2. NON-GUIDELINE MODELS,'/
     3 22X,'IN UNAMAP (VERSION 6) JUL 86.'/
     4 22X,'SOURCE: UNAMAP FILE ON EPA''S UNIVAC 1110, RTP, NC.')
C
C         WRITE HEADER RECORD.
C
      WRITE(9) METNAM,MDATA,MDATB,ND,
     1         ((DESC(I,J), I = 1,18), J = 1,ND)
C
C         WRITE HOURLY RECORDS.
C
      DO 100 I = 1,13
         NLMAX = NLLIM(I)
         WRITE(9) MYR(I),MJD(I),MHR(I),NLMAX,LMX(I),KLASS(I),
     1            (ZL(NL,I),TL(NL,I),WDL(NL,I),UL(NL,I),SAL(NL,I),
     2            SEL(NL,I), NL = 1,NLMAX)
  100 CONTINUE
      STOP
      END
```

APPENDIX C

LSTMET is a program to list data from any meteorological files prepared for input to TUPOS. There are two types of input to the program: A line of identifiers to compare with those on the input file, and a line of data consisting of two date-time groups, a start date-time and an ending date-time. Data with date-times inclusive between these two date-times will be printed. Each date-time consists of a year, Julian day and hour. Upon completion of printing the data included between the two date-times, an additional line of data is read expecting two more date-time groups. If the input data ends without a second line of date, the program will terminate normally. However, if a second line or subsequent lines are present, the data between each pair of date-time groups will be printed. For example, if a met file exists having 31 days' data from 85,001,01 through 85,031,24 and two data lines as

```
85, 017, 15, 85, 018, 14
85, 023, 10, 85, 023, 12
```

are included in the run stream, the first line will cause print out of 24 hours' met data beginning on Julian day 17 at hour 15 and the second line will cause print out of 3 hours' met data beginning on Julian day 23 at hour 10. As can be seen by this example, meteorological data can be skipped to get to those data desired. It is necessary to have the data portions in chronological order. If the two data lines above were reversed, the second data group would not be written.

The data print out is organized so that the printed lines appear as the layers in the atmosphere do with the lower heights above ground at the botton. In order to make the data display of greatest use, the potential temperature change with height, $\sigma\theta/\sigma_z$, for each layer is calculated and included in the data display.

```
C                     LSTMET (VERSION 85095)
C                     A UTILITY PROCESSOR FOR TUPOS IN
C                     SECTION 2. NON-GUIDELINE MODELS,
C                     IN UNAMAP (VERSION 6) JUL 86.
C                     SOURCE: UNAMAP FILE ON EPA'S UNIVAC 1110, RTP, NC.
C         PROGRAM LSTMET.
C          LIST MET DATA FOR SELECTED HOURS.
C
      PARAMETER (NLMAX = 20, NDMAX = 40)
      DIMENSION ZL(NLMAX),TL(NLMAX),WDL(NLMAX),UL(NLMAX),SAL(NLMAX),
     1 SEL(NLMAX),DTHDZ(NLMAX),ALP(NLMAX)
      DIMENSION MID(2),METNAM(2),DESC(18,NDMAX)
      DATA ICON /0/, BLNK /' '/, ASTR /'*'/
      WRITE (6,1234)
 1234 FORMAT ('1',21X,'LSTMET (VERSION 85095)'/
     1 22X,'A UTILITY PROCESSOR FOR TUPOS IN'/
     2 22X,'SECTION 2. NON-GUIDELINE MODELS,'/
     3 22X,'IN UNAMAP (VERSION 6) JUL 86.'/
     4 22X,'SOURCE: UNAMAP FILE ON EPA''S UNIVAC 1110, RTP, NC.')
C        FIRST DATA LINE
C         DATA LABELS TO COMPARE WITH METEOROLOGICAL FILE.
C         MID  8-CHARACTER IDENTIFIER
C         MA   6-DIGIT DATE-TIME ID
C         MB   6-DIGIT TIME ID
      READ (5,1000)MID,MA,MB
 1000 FORMAT (2A4,2I6)
      READ (9) METNAM,MDATA,MDATB,ND,
     1 ((DESC(I,J), I = 1,18), J = 1,ND)
      IF (MID(1).EQ.METNAM(1)) GO TO 10
      ICON = 1
   10 IF (MID(2).EQ.METNAM(2)) GO TO 20
      ICON = 1
   20 IF (MA.EQ.MDATA) GO TO 30
      ICON = 1
   30 IF (MB.EQ.MDATB) GO TO 40
      ICON = 1
   40 IF (ICON.EQ.0) GO TO 50
      WRITE (6,1010) METNAM,MDATA,MDATB,MID,MA,MB
 1010 FORMAT ('0MET DATA FILE IS LABELLED:',2A4,',',I8,',',I8,
     1 ';  EXPECTED:',2A4,',',I8,',',I8,'.')
      STOP
C        LIST HEADER AND DESCRIPTION.
   50 WRITE(6,1020) METNAM,MDATA,MDATB
      WRITE(6,1030) (DESC(J,1), J = 1,18)
      IF (ND .EQ. 1) GO TO 110
      DO 110 N = 2,ND
         WRITE(6,1040) (DESC(J,N), J = 1,18)
  110 CONTINUE
 1020 FORMAT('0MET FILE IDENTIFIER:  ',2A4,/,
     1         1X,'CREATED:  ',I6,' (YR MO DAY)',5X,I6,' (HR MIN SEC)')
 1030 FORMAT(1X,'DESCRIPTION:  ',18A4)
 1040 FORMAT(1X,14X,18A4)
C        SECOND (AND SUBSEQUENT ) DATA LINE.
C          IYR  START PRINT - 2 DIGIT YEAR
C          IJD  START PRINT - JULIAN DAY
C          IHR  START PRINT - HOUR (1-24)
C          JYR  END PRINT - 2 DIGIT YEAR
C          JJD  END PRINT - JULIAN DAY
C          JHR  END PRINT - HOUR (1-24)
   70 READ (5,1050,END=700) IYR,IJD,IHR,JYR,JJD,JHR
C        END OF FILE ENTRY FOR THE ABOVE LINE CAUSES
C         NORMAL TERMINATION.
 1050 FORMAT ()
      WRITE (6,1060) IYR,IJD,IHR,JYR,JJD,JHR
 1060 FORMAT ('0LIST MET DATA FROM:',I3,'/',I3,'/',I2,
     1 '    TO:',I3,'/',I3,'/',I2)
      CALL CHRON (IYR,IJD,IHR,IYDH)
      CALL CHRON (JYR,JJD,JHR,JYDH)
  100 READ (9,ERR=500,END=600) MYR,MJD,MHR,NLLIM,LMX,KLASS,
     1 (ZL(I),TL(I),WDL(I),UL(I),SAL(I),SEL(I), I = 1,NLLIM)
```

```
      CALL CHRON (MYR,MJD,MHR,MYDH)
      IF (MYDH.LT.IYDH) GO TO 100
      IF (MYDH.GT.JYDH) GO TO 70
C
C        LIST MET DATA.
C
      LIM = NLLIM - 1
      DO 200 L = 1,LIM
      LT = L + 1
C        CALCULATE D THETA/DZ BETWEEN LAYERS FOR
C           INCLUSION ON PRINT OUT.
      DTHDZ(L) = (TL(LT) - TL(L))/(ZL(LT) - ZL(L)) + 0.0098
  200 IF (TL(LT).EQ.-9999..OR.TL(L).EQ.-9999.) DTHDZ(L) = -9999.9999
      DO 250 L = 1,NLLIM
      ALP(L) = BLNK
      IF (L.EQ.LMX) ALP(L) = ASTR
  250 CONTINUE
      WRITE (6,1090) MYR,MJD,MHR,LMX,KLASS
 1090 FORMAT ('OMET DATA FOR YEAR:',I3,'  JUL DAY:',I4,'  HOUR:',
     1 I3,'  LMX =',I2,'  KLASS =',I2/' LVL       HT   MIX            ',
     2 'SA        SE        WD        U         T         DTHDZ')
      WRITE (6,1100) NLLIM,ZL(NLLIM),ALP(NLLIM),SAL(NLLIM),SEL(NLLIM),
     1 WDL(NLLIM), UL(NLLIM),TL(NLLIM)
      DO 300 L = 1,LIM
      LT = NLLIM - L
  300 WRITE (6,1100) LT,ZL(LT),ALP(LT),SAL(LT),SEL(LT),WDL(LT),UL(LT),
     1 TL(LT),DTHDZ(LT)
 1100 FORMAT (I3,F10.1,2X,A1,2X,2F10.4,F10.1,2F10.2,F10.4)
      IF (MYDH.EQ.JYDH) GO TO 70
      GO TO 100
  500 WRITE (6,1110)
 1110 FORMAT ('OSYSTEM ERROR ON READING MET DATA RECORD!')
      STOP
  600 WRITE (6,1120)
 1120 FORMAT ('OMET FILE WAS EHAUSTED WITHOUT FINDING DATA FOR THE HOUR
     1REQUESTED!')
      STOP
  700 WRITE (6,1130)
 1130 FORMAT ('0 NORMAL TERMINATION')
      STOP
      END
C
      SUBROUTINE CHRON(IYR,IJD,IHR,IYDH)
C        CHRON-CONVERT-DATE
C
C        ARGUMENT LIST:
C           INPUT:    IYR  - YEAR (2 DIGITS)
C                     IJD  - JULIAN DAY (3 DIGITS)
C                     IHR  - HOUR (2 DIGITS)
C           OUTPUT:   IYDH - DATE CONVERTED TO HOUR
C
C        CALLING ROUTINES:
C           TU220, TU320, TU325
C
C        DESCRIPTION:
C           THIS SUBROUTINE CONVERTS DATES BETWEEN 1960 AND 1999 TO A
C           COMMON SEQUENTIAL HOUR.  THE ZERO POINT IS 1959, 365, 24,
C           I.E., HOUR 1 IS THE FIRST HOUR OF 1960.
C
      DIMENSION ICUM(41),NDAY(40)
      DATA IO/6/
      DATA ICUM/      0,  8784, 17544, 26304, 35064, 43848, 52608,
     1          61368, 70128, 78912, 87672, 96432,105192,113976,
     2         122736,131496,140256,149040,157800,166560,175320,
     3         184104,192864,201624,210384,219168,227928,236688,
     4         245448,254232,262992,271752,280512,289296,298056,
     5         306816,315576,324360,333120,341880,350640/
      DATA NDAY/366,365,365,365,
     1          366,365,365,365,
     2          366,365,365,365,
     3          366,365,365,365,
     4          366,365,365,365,
     5          366,365,365,365,
     6          366,365,365,365,
     7          366,365,365,365,
     8          366,365,365,365,
     9          366,365,365,365/
      DATA IZPT/59/
C
C          SCREEN INPUT.
C
      IF ((IYR .GT. 59) .AND. (IYR .LT. 100)) GO TO 100
      WRITE(IO,1000) IYR
      GO TO 990
C
  100 IF ((IJD .GT. 0) .AND. (IJD .LT. 367)) GO TO 200
      WRITE(IO,1010) IJD
      GO TO 990
C
  200 IF ((IHR .GT. 0) .AND. (IHR .LT. 25)) GO TO 300
      WRITE(IO,1020) IHR
      GO TO 990
C
  300 NYR = IYR - IZPT
      IF (IJD .LE. NDAY(NYR)) GO TO 400
      WRITE(IO,1030) IJD,IYR
      GO TO 990
C
C          CONVERT YEAR/JULIAN DAY/HOUR TO COMMON SEQUENTIAL HOUR.
C
  400 IYDH = ICUM(NYR) + (IJD - 1) * 24 + IHR
      GO TO 999
C
C          ERROR PROCESSING.
C
  990 IYDH = -999999
C
  999 RETURN
C
C          FORMAT STATEMENTS.
C
 1000 FORMAT('0*** YEAR INPUT (',I4,') IS NOT WITHIN RANGE OF 60-99.')
 1010 FORMAT('0*** JULIAN DAY INPUT (',I4,') IS NOT WITHIN RANGE OF ',
     1       '1-366.')
 1020 FORMAT('0*** HOUR INPUT (',I4,') IS NOT WITHIN RANGE OF 1-24.')
 1030 FORMAT('0*** JULIAN DAY INPUT (',I4,') CANNOT BE USED FOR YEAR ',
     2       I2,'; THIS IS NOT A LEAP YEAR.')
      END
```

APPENDIX D

INMET is a program that will allow creation of a meteorological data file compatible with the input requirements of TUPOS. This program would be of greatest use, when it is desirable to create a file for a short period of record, such as, for just several hours.

Data type 1 consists of the indentifiers to be used on the header record on the meteorological file plus ND, the number of lines of the description. Data type 2 is a line of alphanumeric description of the met file. Lines of data type 2 are repeated ND times in the run stream. The header record in the meteorological file is created from type 1 and type 2 inputs.

Data type 3 contains values for six variables. The first three are year, Julian day and hour. The fourth is the number of levels in the vertical for which data will be furnished. The fifth is the number of the level that corresponds to the mixing height or the top of the nocturnal boundary layer height. The sixth is the stability classification: 1 = unstable, 2 = daytime neutral, 3 = nighttime neutral, and 4 = stable.

There is a data type 4 line of input for each of the number of levels given in data type 3. A value is given for each of the following six or seven (see following) variables: height above ground of the level, temperature for this height, wind direction for this height, wind speed for this height, standard deviation of wind azimuth angle, standard deviation of wind elevation angle, and the change of potential temperature with height between this level and the next.

It should be noted that although the change of potential temperature with height, $\delta\theta/\delta_z$, is not a data parameter to be placed in the meteorological file, it may be a parameter that the user may want to adjust. Therefore, the user has the choice of providing temperatures for each level, in which case, the DTHDZ may be left off on the data input; or providing a temperature for only the lowest level and a value for $\delta\theta/\delta_z$ for that level and each subsequent level except the last, and allowing the temperatures for the data file to be calculated from the first level temperature and the $\delta\theta/\delta_z$ for each layer. For the latter case, zero is supplied for all temperatures except that for the first level and $\delta\theta/\delta_z$ is given in the input data for all but the last layer.

```
C
C                         INMET (VERSION 85094)
C                         A UTILITY PROCESSOR FOR TUPOS IN
C                         SECTION 2. NON-GUIDELINE MODELS,
C                         IN UNAMAP (VERSION 6) JUL 86.
C                         SOURCE: UNAMAP FILE ON EPA'S UNIVAC 1110, RTP, NC.
C           CREATE MET FILE.
      PARAMETER (NLMAX = 20, NDMAX = 40)
      DIMENSION ZL(NLMAX),TL(NLMAX),WDL(NLMAX),UL(NLMAX),SAL(NLMAX),
     1 SEL(NLMAX),DTHDZ(NLMAX)
      DIMENSION METNAM(2),DESC(18,NDMAX)
      WRITE (6,1234)
 1234 FORMAT ('1',21X,'INMET (VERSION 85094)'/
     1 22X,'A UTILITY PROCESSOR FOR TUPOS IN'/
     2 22X,'SECTION 2. NON-GUIDELINE MODELS,'/
     3 22X,'IN UNAMAP (VERSION 6) JUL 86.'/
     4 22X,'SOURCE: UNAMAP FILE ON EPA''S UNIVAC 1110, RTP, NC.')
C        FIRST DATA LINE
C        METNAM(2)  AN 8 CHARACTER ALPHANUMERIC IDENTIFIER FOR THE MET
C                     DATA.
C        MDATA      DATE-TIME OF DATA CREATION, MO DAY YR (6 DIGITS)
C        MDATB      DATE-TIME OF DATA CREATION, HR MIN SEC (6 DIGITS)
C        ND         NUMBER OF 72 CHARACTER ALPHANUMERIC LINES OF
C                     DESCRIPTION.
      READ (5,1000) METNAM,MDATA,MDATB,ND
 1000 FORMAT (2A4,2I6,I3)
      DO 10 J = 1,ND
C        NEXT "ND" LINES.
C          DESC  DESCRIPTION OF MET DATA.
   10 READ (5,1010) (DESC(I,J), I = 1,18)
 1010 FORMAT (18A4)
C        THE ABOVE INPUTS COMPLETES THE HEADER INFO.
      WRITE (9) METNAM,MDATA,MDATB,ND,
     1 ((DESC(I,J), I = 1,18), J = 1,ND)
      NREC = 0
C        DATA TYPE 3
C        MYR        YEAR (2 DIGITS)
C        MJD        JULIAN DAY (3 DIGITS)
C        MHR        HOUR (2 DIGITS)
C        NLLIM      NUMBER OF DATA LEVELS THIS HOUR
C        LMX        THE DATA LEVEL NUMBER OF THE MIXING HEIGHT
C        KLASS      THE STABILITY CATEGORY FOR THIS HOUR
   20 READ (5,1020,ERR=500,END=600) MYR,MJD,MHR,NLLIM,LMX,KLASS
 1020 FORMAT ()
      DO 30 L = 1,NLLIM
C        DATA TYPE 4 ("NLLIM" OF THESE)
C        ZL         HEIGHT OF EACH LEVEL (METERS ABOVE GROUND)
C        TL         TEMPERATURE (K) FOR EACH LEVEL
C        WDL        WIND DIRECTION (DEGREES AZIMUTH, CLOCKWISE FROM
C                     NORTH) FOR EACH LEVEL
C        UL         WIND SPEED (M/SEC) FOR EACH LEVEL
C        SAL        SIGMA-A STANDARD DEVIATION OF WIND AZIMUTH
C                     (RADIANS) FOR EACH LEVEL
C        SEL        SIGMA-E STANDARD DEVIATION OF WIND ELEVATION ANGLE
C                     (RADIANS) FOR EACH LEVEL
C         DTHDZ     D THETA/DZ FOR THE LAYER WHOSE BASE
C                     IS AT THIS LEVEL.
C           DTHDZ SHOULD BE ENTERED AS ZERO IF YOU GAVE AN
C            ENTRY FOR TEMPERATURE, TL.
C           CAN OPTIONALLY INPUT ZERO FOR TL FOR SECOND AND
C            SUBSEQUENT LAYERS.  THIS WILL HAVE THE EFFECT
C            OF CALCULATING THE TEMPERATURE FOR THAT HEIGHT
C            FROM THE FURNISHED D THETA/DZ FOR THE LAYER
C            WHOSE TOP IS AT THIS HEIGHT.
      READ (5,1020,ERR=500,END=600) ZL(L),TL(L),WDL(L),UL(L),SAL(L),
     1 SEL(L),DTHDZ(L)
      IF (TL(L).EQ.0.) TL(L) = (DTHDZ(L-1) - 0.0098) * (ZL(L) - ZL(L-1))
     1 + TL(L-1)
   30 CONTINUE
      WRITE (9) MYR,MJD,MHR,NLLIM,LMX,KLASS,
     1 (ZL(I),TL(I),WDL(I),UL(I),SAL(I),SEL(I), I = 1,NLLIM)
      NREC = NREC + 1
      GO TO 20
  500 WRITE (6,1110)
 1110 FORMAT ('0SYSTEM ERROR ON READING MET DATA RECORD!')
      STOP
  600 WRITE (6,1030) NREC
 1030 FORMAT ('0NORMAL TERMINATION.',I4,' HOURLY RECORDS WRITTEN TO FILE
     1 9.')
      STOP
      END
C
C         TEST INPUT FOR INMET PROVIDED BELOW WILL PRODUCE THE
C          SAME DATA SET THAT CAN BE PRODUCED BY METVER WHICH
C          CAN BE USED TO RUN THE TEST FOR TUPOS.
C
C        DATA BEGINS ON NEXT LINE.
SET6    840210105523  5
SYNTHETIC DATA SET WITH HOURS MISSING AND DATA MISSING.
DATA AVAILABLE FOR HOURS: 15,16,17,21,22,23,02,03,04,07,08,09, AND 14.
NO DATA FOR HOURS: 18,19,20,24,01,05,06,10,11,12, AND 13.
HOUR 21 HAS ONLY 3 LEVELS.  SOME TEMPERATURES ARE MISSING FOR HOUR 02.
VARIATION APPROXIMATES A CLEAR DAY AND NIGHT.
83,365,15,6,4,1
50.,293.5,263.,2.3,0.219,0.134,0.
100.,293.,265.,2.4,0.198,0.152,0.
200.,292.,268.,2.5,0.178,0.172,0.
1500.,285.5,270.,4.5,0.132,0.248,0.
1600.,287.5,272.,7.,0.130,0.251,0.
1800.,286.5,273.,8.,0.128,0.256,0.
83,365,16,6,4,1
50.,293.3,264.,2.26,0.209,0.123,0.
100.,293.,266.,2.4,0.189,0.134,0.
200.,293.,268.,2.5,0.164,0.142,0.
1500.,285.5,269.,4.5,0.138,0.161,0.
1600.,287.5,271.,7.,0.124,0.176,0.
1800.,286.5,273.,8.,0.107,0.183,0.
83,365,17,6,4,1
50.,293.1,265.,2.23,0.197,0.112,0.
100.,293.,267.,2.4,0.174,0.111,0.
200.,292.5,269.,2.5,0.158,0.110,0.
1500.,285.5,271.,4.5,0.142,0.108,0.
1600.,287.5,272.,7.,0.118,0.107,0.
1800.,286.5,273.,8.,0.094,0.106,0.
83,365,21,6,2,4
50.,292.,258.,2.,0.132,0.091,0.
100.,292.,262.,2.2,0.111,0.078,0.
200.,291.8,265.,2.5,0.092,0.064,0.
1000.,-9999.,-9999.,-9999.,-9999.,-9999.,0.
1200.,-9999.,-9999.,-9999.,-9999.,-9999.,0.
1400.,-9999.,-9999.,-9999.,-9999.,-9999.,0.
83,365,22,6,4,4
50.,291.5,256.,1.9,0.119,0.082,0.
100.,291.7,261.,2.13,0.099,0.069,0.
200.,291.8,263.,2.5,0.085,0.058,0.
1500.,285.5,270.,4.5,0.055,0.047,0.
1600.,287.5,272.,7.,0.048,0.041,0.
1800.,286.5,275.,8.,0.046,0.041,0.
83,365,23,6,4,4
50.,291.,254.,1.8,0.105,0.070,0.
100.,291.3,260.,2.06,0.085,0.061,0.
200.,291.7,263.,2.5,0.070,0.053,0.
1500.,285.5,271.,4.5,0.037,0.045,0.
1600.,287.5,272.,7.,0.036,0.038,0.
1800.,286.5,273.,8.,0.035,0.032,0.
84,001,02,6,4,4
50.,289.8,256.,1.5,0.079,0.052,0.
100.,290.,258.,1.86,0.067,0.043,0.
200.,-9999.,263.,2.5,0.056,0.038,0.
1500.,-9999.,272.,4.5,0.049,0.036,0.
```

```
1600.,287.5,271.,7.,0.038,0.031,0.
1800.,286.5,270.,8.,0.027,0.026,0.
84,001,03,6,4,4
50.,289.5,255.,1.4,0.075,0.046,0.
100.,289.7,258.,1.8,0.066,0.039,0.
200.,291.5,264.,2.5,0.050,0.035,0.
1500.,285.5,271.,4.5,0.041,0.031,0.
1600.,287.5,271.,7.,0.033,0.027,0.
1800.,286.5,271.,8.,0.024,0.024,0.
84,001,04,6,4,4
50.,289.2,254.,1.32,0.069,0.041,0.
100.,289.6,257.,1.76,0.058,0.036,0.
200.,291.5,262.,2.5,0.045,0.031,0.
1500.,285.5,269.,4.5,0.032,0.026,0.
1600.,287.5,270.,7.,0.027,0.022,0.
1800.,286.5,272.,8.,0.021,0.020,0.
84,001,07,6,4,3
50.,288.7,252.,1.4,0.048,0.032,0.
100.,289.5,258.,1.8,0.039,0.028,0.
200.,291.5,265.,2.5,0.032,0.024,0.
1600.,286.5,271.,7.,0.017,0.016,0.
1800.,290.5,273.,8.,0.016,0.015,0.
2000.,289.5,276.,9.,0.016,0.015,0.
84,001,08,6,4,3
50.,289.,253.,1.6,0.052,0.041,0.
100.,289.6,260.,1.9,0.043,0.038,0.
200.,291.5,266.,2.5,0.035,0.032,0.
1600.,285.5,270.,7.,0.026,0.023,0.
1800.,289.5,272.,8.,0.024,0.018,0.
2000.,288.5,274.,9.,0.022,0.017,0.
84,001,09,6,4,2
50.,289.9,255.,1.9,0.071,0.056,0.
100.,290.,262.,2.1,0.061,0.048,0.
200.,291.5,267.,2.5,0.050,0.041,0.
1600.,284.5,271.,7.,0.040,0.034,0.
1800.,288.5,272.,8.,0.034,0.021,0.
2000.,287.5,272.,9.,0.030,0.019,0.
84,001,14,6,4,1
50.,294.7,264.,2.3,0.205,0.129,0.
100.,294.1,266.,2.4,0.194,0.149,0.
200.,293.,268.,2.5,0.175,0.168,0.
1600.,279.,269.,5.,0.132,0.228,0.
1800.,283.,271.,8.,0.130,0.234,0.
2000.,282.,270.,9.,0.127,0.241,0.
C          DATA ENDS ON PREVIOUS LINE.
```

Date ____________________

Chief, Environmental Operations Branch
Meteorology and Assessment Division (MD-80)
U. S. Environmental Protection Agency
Resrch Tri Pk, NC 27711

I would like to receive future revisions to the "TUPOS User's Guide."

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